PENNSYLVANIA
GEOLOGICAL SURVEY
FOURTH SERIES

TOPOGRAPHIC AND GEOLOGIC

ATLAS

of

PENNSYLVANIA

NO. 37

GREENSBURG QUADRANGLE

MINERAL RESOURCES

By

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LETTER OF TRANSMITTAL.

R. Y. Stuart, Secretary,

Department of Forests and Waters.

Sir:—

I have the honor to submit herewith a detailed report on the Economic Geology of the Greensburg Quadrangle, by Meredith E. Johnson. This is part 37 of the Topographic and Geologic Atlas of Pennsylvania, of which part 206 (Allentown area) has just been published. It is the first of these parts that is entirely the work of the present Survey. Because of the approaching exhaustion of the Pittsburgh coal in this area, special attention has been given to securing and presenting data on the other coal beds that must form the basis of coal mining in this region in the future. While this atlas sheet takes its place among many other similar publications (folios and economic bulletins) previously published by the U. S. Geological Survey on the geology of western Pennsylvania as the result of cooperative studies with the State, it is believed that this report is an improvement over the others in the quantity of information on the less important mineral resources.

Respectfully,

Geo. H. Ashley

State Geologist.

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Mineral Resources of the Greensburg Quadrangle, Westmoreland County, Pennsylvania

By Meredith E. Johnson

INTRODUCTION

Two of the best known coal mining districts in Pennsylvania are the Irwin and Greensburg basins. Between these basins and west and east of them are anticlines which are equally well known to oil and gas men on account of the tremendous amount of gas which has been and is still being obtained from them. In addition to these natural resources this area contains widespread beds of limestone, sandstone, shale, sand, and clay. Although the coal and gas have been exploited for many years, the value of the coal and gas remaining is in all probability equal to if not greater than that already taken out. The other resources have hardly been touched. It was because of the great value of these economic resources that this area was chosen by the State Geologist, George H. Ashley, as one of the first in which to do detailed geologic work.

The present report treats of a quadrangular area including much of the Greensburg and Irwin coal basins and considerable territory adjacent to these basins.

In this report the attempt has been made to give not only detailed information as to the mineral resources of the quadrangle, but also details of the stratigraphy of the region—something that has not been attempted heretofore. The field work for the report was done in the summer and fall of 1921 by a party composed of C. A. Bonine (in charge), C. W. Robinson, C. K. Graeber and P. S. Schoeneck. Later in the season the writer who had been in charge of geologic work in the Pittsburgh quadrangle, and C. J. Campbell, geologic aid, moved over to the Greensburg quadrangle to help finish the field work in that quadrangle before winter set in.

LOCATION AND AREA.

In accordance with the settled policy of the State and of the United States Geological Survey in making a topographic map, the Greensburg quadrangle consists of the territory included between 15 minute meridian lines and parallels; in this case, meridians 79° 30′ and 79° 45′, and parallels 40° 15′ and 40° 30′. This constitutes an area of about 227 square miles. It is bounded on the

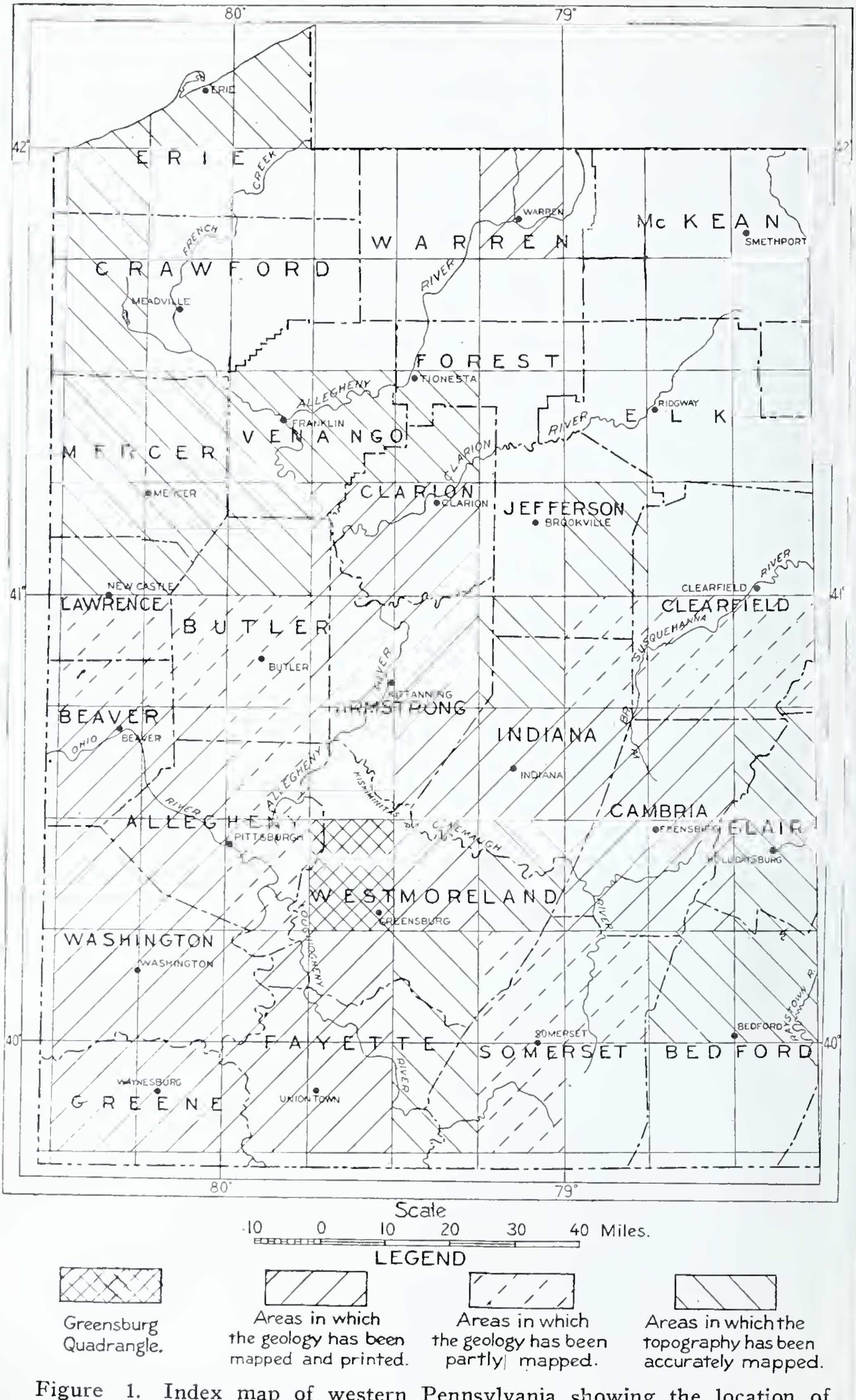

Figure 1. Index map of western Pennsylvania showing the location of the Greensburg quadrangle, and extent of topographic and geologic mapping.

north, east, south, and west respectively, by the Freeport, Latrobe, Connellsville and Pittsburgh quadrangles. The western boundary of the quadrangle is less than six and one-half miles east of the city limits of Pittsburgh. Most of the quadrangle lies in the western part of Westmoreland County but it also includes a small part of eastern Allegheny County.

TRANSPORTATION FACILITIES.

The Greensburg quadrangle is well supplied with railway facilities. The main line of the Pennsylvania Railroad crosses it in an east-west direction, and its branches furnish transportation to the areas north and south of the main line. Various trolley lines connect the larger towns and provide a cheap means of transportation between them. None of the streams are large enough to be used for transportation purposes.

There are many excellent roads in the quadrangle, some of which carry a tremendous amount of traffic. The best known is the Lincoln Highway. The advent of the motor car and motor truck has caused more and more traffic to be diverted from the railroads to this important highway. Hundreds of tons of merchandise are transported daily over this road in either direction. The stream of traffic keeps up all the year, heavy snows being quickly removed by motor snow-plows. It is seldom that the road is closed to traffic for more than a week even in the severest weather. Good roads have been of tremendous value to the farmer and the small coal operator in helping them get their products to market more speedily and cheaply than before.

CITIES AND TOWNS.

The quadrangle derives its name from the city of Greensburg, the largest city in the quadrangle and the county seat of Westmoreland County. In 1920 Greensburg had a population of 15,033. The population is in large measure supported by the coal industries, although there are many other less important industries in the city.

Jeannette is the second largest city in the quadrangle and had in 1920 a population of 10,627. The glass works and the Pennsylvania Rubber Company provide employment for most of the workmen. Towns of lesser importance are Irwin and Herminie (both coal mining towns in the Irwin basin), Penn and Manor. There are in addition many small coal mining towns and other small communities scattered over the quadrangle.

PREVIOUS GEOLOGIC WORK.

Considerable geologic work has been done in the Greensburg quadrangle in the past years but little of this has been of a detailed nature.

As far back as 1858, H. D. Rogers, Pennsylvania's first State Geologist, drew up a section denoting the structure of the rocks along the main line of the Pennsylvania Railroad from Pittsburgh to Altoona which clearly showed the series of anticlines and synclines along the railroad in the Greensburg quadrangle. In his report[1] he gives sections of the Pittsburgh coal in the Greensburg and Irwin basins, gives the approximate boundaries of the basins, and also gives columnar sections. Although his columnar sections were measured apparently with little or no allowance for structure, they are interesting and, under the circumstances, remarkably good.

The Pennsylvania Second Geological Survey took up the problem of the geology of the State where Rogers left off, mapping it in a more detailed manner and working out the geology of the different counties by townships. Volume KK of the Second Survey, published in 1877, describes the geology of the Greensburg quadrangle (and adjacent territory) and was used in getting some of the details given in this report.

Since 1877 very little geologic work has been done in this region. Bulletin No. 65 of the U. S. Geological Survey[2] gives a section of the Allegheny group at Murrysville as derived from a churn drill bore-hole. J. J. Stevenson[3] mentions the region and gives several bore-hole sections in his "Carboniferous of the Appalachian Basin." More recently, Percy E. Raymond[4] published several sections measured along the main line of the Pennsylvania Railroad. Of detailed geologic mapping, there has been practically none.

ACKNOWLEDGMENT.

The writer takes pleasure in acknowledging his indebtedness to the many engineers, coal operators, oil and gas companies, and others in the Greensburg and Pittsburgh districts without whose kind assistance it would have been impossible to write this report.

To R. W. Stone, Assistant State Geologist, grateful acknowledgement is made for critical reading and editing of the entire report.

TOPOGRAPHY.

CHARACTER.

The Greensburg quadrangle is in the Allegheny Plateau region and the general elevation of the hilltops varies little. An examination of the topographic map (Plate I) shows that although the quadrangle is drained in all directions, there is a general rise from

[1]Rogers, H. D., Geology of Pennsylvania, Vol II, p. 629, 1858.

[2]White, I. C., Stratigraphy of the bituminous coal field of Pennsylvania, Ohio, and West Virginia: U. S. Geol. Survey Bull. No. 65, p. 114, 1891.

[3]Stevenson, J. J., Carboniferous of the Appalachian Basin: Bull. Geol. Soc. Amer., Vol. 17, pp. 65-228, 1906; Vol. 18, pp. 29-178, 1907.

[4]Raymond, Percy E., Some sections of the Conemaugh series between Pittsburgh and Latrobe,

the western border, where the more important streams have an elevation of 780 to 800 feet above sea level, towards the east. This is illustrated by the grade of the main line of the Pennsylvania Railroad, which is 1175 feet above sea level at the eastern border and 840 feet at the western border of the quadrangle. The elevation of points in the quadrangle ranges from 780 to 1510 feet above sea level. The greatest relief, or the difference in altitude of hills and adjacent valleys, is about 450 feet and occurs just south of Eisaman, Hempfield township. Generally the relief varies from 100 to 400 feet. In any one locality the hills do not vary greatly in height.

The topography is typical of that type known to physiographers as "mature"; that is, hill slopes predominate rather than valley flats or upland flats. A cross section through any part of the quadrangle would show undulating hills separated by only moderately broad valleys. This fact is brought out by the contour lines (lines drawn through points of equal elevation above some accepted datum plane—usually mean sea level) on the topographic map. Some typical hill slopes are shown in Plate II.

STREAMS.

There are no large streams in the quadrangle. Brush Creek, Turtle Creek and Beaver Run all drain about equal areas. The first two of these streams have their source near the center of the quadrangle and flow in a westerly direction. They unite at Trafford City, a town just beyond the western border of the quadrangle. Beaver Run has its source about four miles north of Greensburg and flows almost due north. It has in general a straight course in comparison with Brush Creek and the lower part of Turtle Creek. All three of these streams, and also Little Sewickley Creek in the south, and Pucketa Creek in the north, cut across the structure. It is generally believed that after the rocks were folded a long period of erosion ensued, during which all of the rocks were worn down to a gently sloping plain, on which developed the streams somewhat as they occur today. Later the plane which covered much of the Appalachian region was raised, and the streams sunk their channels irrespective of the underlying structure, forming what are called "intrenched meanders." Both Brush Creek and Turtle Creek maintained their former winding courses and cut down through the upturned rocks of the Murrysville anticline as though that structure did not exist. Today the lower courses of these streams exhibit typical entrenched meanders. On the other hand, some of the smaller streams and branches apparently were diverted from their original courses and followed the synclines where shales made downcutting easy. Brush Run, and the streams flowing from the northeast and emptying into Little Sewickley Creek at Herminie, are

A. View near Mamont showing bench on Birmingham shale.

B. On Pope Run northeast of Mamont

Typical hill slopes in the Greensburg quadrangle.

PLATE III

GENERALIZED COLUMNAR SECTION FOR THE GREENSBURG QUADRANGLE

SCALE 1 INCH=100 FEET

System	Series	Group	Symbol	Avg. thickness (feet)	Names of strata	General character of groups
PERMIAN	DUNKARD	Washington	Cd	140+	Washington coal Little Washington coal Colvin Run limestone Waynesburg A coal and Mount Morris limestone Waynesburg sandstone	Composed largely of friable arkose sandstones and sandy shale. One important limestone member occurring only in southern part of Irwin syncline. Several unimportant coal beds.
PENNSYLVANIAN	PITTSBURGH	Monongahela	Cm	380	Waynesburg coal Little Waynesburg coal Waynesburg limestone Uniontown sandstone Uniontown coal Benwood limestone "Beech" sandstone and coal Benwood limestone Sewickley sandstone and coal Fishpot limestone Redstone coal and limestone Pittsburgh sandstone Thin local coal bed Pittsburgh coal	Prevailingly calcareous, particularly in the southern part of the quadrangle. Increasing percentage of sandstone towards the northeast. Contains three important coal beds.
		Conemaugh	Ccm	600	Thin local coal bed Pittsburgh limestone Thin local coal bed Connellsville sandstone Thin local coal bed Clarksburg limestone Morgantown sandstone Wellersburg coal, clay and limestone Duquesne coal and clay Ames limestone Harlem coal Upper Bakerstown coal Woods Run limestone Lower Bakerstown coal Saltsburg sandstone Pine Creek limestone and coal Buffalo sandstone Brush Creek limestone Brush Creek coal Mahoning coal Mahoning sandstone	Composed chiefly of shale. Sandstone beds are locally very thick and prominent. Contains several coal beds which locally are thick enough to mine, but only two of which are being mined today (1923). The upper half of the group includes two limestone beds which in the southern half of the quadrangle are frequently thick enough to make it profitable to quarry them. The lower half of the group contains three thin fossiliferous limestone beds which are important stratigraphic "markers". The red beds of this group are often conspicuous in the landscape.
		Allegheny	Ca	285	Upper Freeport coal Lower Freeport coal Upper Kittanning coal Middle Kittanning coal Lower Kittanning coal Clarion (?) coal Brookville coal	An important coal-bearing group. Only one coal bed outcrops in the quadrangle, but two others are important and will some day be mined. The group is composed chiefly of gray shales, although sandstones are locally important.
	POTTSVILLE		Cpv	190	Homewood sandstone Mercer coal Connoquenessing sandstone Sharon coal	This group does not outcrop within the quadrangle, but farther east the sandstones form conspicuous features of the topography.
MISSISSIPPIAN	MAUCH CHUNK		Cmc	40		Composed of red and green shales and usually some limestone.

Sections and correlations of deep wells in the Greensburg Quadrangle

examples of this. That this upward movement of the surface ceased some time ago is indicated by the fact that the streams are now beginning to form flats along their courses.

INFLUENCE OF ROCKS ON TOPOGRAPHY.

The slopes and the configuration of the hills are to a large extent controlled by the nature of the underlying rocks. Thus, a hill composed of shale with a massive sandstone at the top, will have moderately steep slopes and a broad flat top; a hill composed entirely of sandstone would be steeper and more rugged; and a hill composed of shale would have gentle slopes and a rounded outline. It is much easier to note this difference in the field than on a topographic sheet. In the field, dip slopes, or hills of which one slope conforms to the dip of the strata, are frequently observed. Since the surface formations in this quadrangle are composed of several types of sedimentary deposits the higher hills are apt to reflect this in gentle slopes broken by hard sandstone ledges which sometimes can be traced for long distances around the hills. Use was made of these ledges in determining the structure in areas of low relief where outcrops are poor and scarce.

STRATIGRAPHY.

INTRODUCTORY STATEMENT.

The surface rocks in this quadrangle belong chiefly in the Conemaugh and Monongahela groups of the Pennsylvania sub-system. Alluvial deposits and small areas of the Allegheny and Washington groups constitute the remainder. No igneous or metamorphic rocks occur in this region. Of the consolidated rocks, limestones, sandstones, shales, clays and coals are represented. These rocks constitute a total exposed section of some 1220 feet. It is only because the rocks are folded that this much of the stratigraphic section is seen. Were the rocks absolutely flat only 730 feet of the section would be exposed, as this represents the difference in altitude of the highest and lowest points in the quadrangle.

From diamond drill-hole records and a few well-kept churn drill-hole records it is possible to continue the detailed section down to the Greenbrier limestone in the Mauch Chunk red shales (See Plate III). This adds some 400 feet more of sandstone, shales, coals, limestones and clays to those that crop out. The nature of the underlying formations penetrated by churn drill-holes is shown in Plate IV and includes those members below the Greenbrier limestone which have been penetrated by the drill.

Accepting arbitrarily the limits already defined[5] for the different groups, it will be seen that the Monongahela is given an average thickness of 380 feet for the whole quadrangle, the Conemaugh a thickness of 660 feet, the Allegheny 285 feet, the Pottsville 180 feet, and so on.

An effort was made in drawing the columnar section to indicate the extreme variability of the strata. Not only do the thicknesses of the various groups and formations within the groups change from place to place, but the change in the nature of an individual member in distances of a hundred yards or less is sometimes startling. For instance, a massive sandstone 60 feet thick has been seen to pinch down to less than 15 feet in a horizontal distance of less than 150 feet. When first seen in the field such a startling change naturally suggests an unconformity. If a closer study be made, however, it is possible to determine that such apparent erosional unconformities are in reality due to sudden changes in the material which was being deposited, and that probably 100 yards farther along the sandstone will be 40 feet or more thick. One should think of the strata hereafter described, not as persistent, homogeneous beds of uniform composition and thickness, but as strata composed of lenses and layers of sandstone, shale, etc., of variable thickness which have been deposited one on top of another like the layers in a cake. The closest analogy perhaps to such a formation is to be seen in a cross-section of a piece of banded gneiss. Although the bands of light and dark material vary in thickness and internal arrangement, such bands extend for long distances and retain a similar appearance throughout. Similarly, the various groups, formations, and members within the formations, vary considerably from place to place, but in general retain the same characteristics. For example, the Monongahela contains a much larger percentage of limestone than the lower groups, the Allegheny contains a greater percentage of coal, the Pottsville is persistently sandy, and the Conemaugh consists largely of shales.

From the foregoing description it can be readily understod that not only is it difficult to make a columnar section which will adequately represent the nature of the rocks over the whole quadrangle, but variations in the strata also made the work of correlation and mapping in the field equally difficult. Of the different members mapped, by far the most useful were the Pittsburgh coal and the Ames limestone. These two beds outcrop over large areas and change so little in appearance that they can always be quickly and easily recognized. Unfortunately there are areas in which both of these members have been eroded and there the mapping was much more difficult. Inside the Irwin and Greensburg basins, where both the Ames lime-

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[5] Ashley, G. H., A geologic time scale; Eng. and Min. Jour. Press, Vol. 115, No. 25, pp. 1106-1109, 1923.

stone and Pittsburgh coal are below the surface, it was necessary to depend largely upon the upper coals and the Waynesburg sandstone for "markers."

Although individual beds are given names in the columnar section, no claim is made that each bed in every case represents the same bed bearing that name at the type locality. It is true that before the rocks of this region were folded into anticlines and synclines the Pittsburgh coal bed undoubtedly was continuous from the type locality at Pittsburgh to many miles east of Greensburg. Likewise the Redstone coal, the Ames limestone, and several other members are widespread, and not only is the correlation correct in such cases, but it refers to exactly the same bed. In the case of the Connellsville, Morgantown and other sandstones, however, the names as applied are given to sandstones which occur at about the same horizon in the stratigraphic section as they do in their type locality, although it is known that these sandstones do not extend continuously from the type locality but are in places entirely replaced by shale, clay or other material. This applies also to many of the limestones and thinner coals. In such cases the names are used merely as a matter of convenience.

CLASSIFICATION OF ROCKS.

The outcropping rocks and those penetrated by the drill have been classified as follows:

- Quaternary System
- Carboniferous System
  - Permian sub-system
    - Dunkard series
      - Washington group
  - Pennsylvanian sub-system
    - Pittsburgh series
      - Monongahela group
      - Conemaugh group
      - Allegheny group
    - Pottsville series
  - Mississippian sub-system
    - Mauch Chunk series
      - Mauch Chunk group
      - Greenbrier group
    - Pocono series
- Devonian System
  - Upper Devonian series
  - Middle " "
  - Lower " "

The rocks will be described in decending order. All descriptions are understood to refer to this quadrangle alone and when it is said that the Mauch Chunk red shale varies from zero to 100 feet in thickness, that means for this area alone and does not mean that red shale may not be 200 feet thick in an adjacent quadrangle.

QUATERNARY DEPOSITS.

The Quaternary deposits of this region are of recent age and comprise only those loose sands and gravels which are to be found in the beds and flood plains of the present-day streams. In the stream beds the gravels and sands are as a rule mixed or unassorted. The flood plains, however, usually consist of a fine, loamy soil which makes excellent farming land. From the farmers' viewpoint it is unfortunate that the flood plains are of such limited extent.

CARBONIFEROUS SYSTEM.

DUNKARD SERIES—WASHINGTON GROUP.

The Dunkard series comprises those rocks from the top of the Waynesburg coal to the top of the stratigraphic section in this region. None of the Greene group and only that part of the Washington group which is below the Washington limestone were found in the Greensburg quadrangle. The members above the Waynesburg sandstone occur only in the Irwin basin, the greatest thickness noted, 140 feet, being between Irwin and Herminie.

The Washington group is usually near the tops of the hills and a good section could be obtained at few places. Nevertheless enough sections were measured to give a fairly good idea of the character of the lower part of the group in this area.

Section of Washington group between Rillton and Edna No. 2.

	Ft.	in.
Coal, shaly, Washington (reported)	5	
Concealed (sandy shale fragments)	16	
Coal, Little Washington		10
Clay	2	
Concealed	20	
Shale, sandy	3	
Fire-clay, gray		3
Shale, sandy	2+	
Concealed	5	
Limestone	10	
Concealed (sandstone fragments)	24	
Coal, Waynesburg A (reported)	2 to 6	
Shale, dark gray	3	
Concealed	7	
Limestone	1	
Concealed	2	
Limestone	1	
Clay	2	
Sandstone, massive Waynesburg	15	

Washington coal. The Washington group is composed chiefly of sandy shales and limestone. The highest (stratigraphically) member observed was a sandy shale just above the Washington coal. This coal bed, occurring in the tops of the higher hills southeast of Irwin at an average distance of 120 feet above the Waynesburg coal, is an impure, shaly coal averaging from three to five feet thick, which makes a broad black smear wherever it outcrops in a road. The following section illustrates its usual character:

Section of Washington coal one mile east of Chambers.

	Ft.	in.
Shale, carbonaceous		10
Clay		8
Coal		10
Clay		8
Coal	2	
Shale		

Little Washington coal. The interval down to the Little Washington coal is usually occupied by a sandy shale. This interval averages about 15 feet in the Irwin basin. The little Washington coal is a thin but persistent bed of good, blocky coal which attains a maximum thickness of 18 inches in this area. The following sections illustrate its character:

Section of Little Washington coal one mile east of Rillton

	In.
Coal	2
Fireclay	2
Shale, carbonaceous	3
Clay	3
Coal	6+ (base not seen)

Section of Little Washington coal one mile north of Edna No. 2 mine

	Ft.	in.
Sandstone		
Coal	1	6
Sandstone, shaly	3+	

Section of Little Washington coal one mile east of Chambers

	Ft.	in.
Coal, shaly		10
Clay	2	

Colvin Run limestone. Shale and sandstone fill the interval between the Little Washington coal and the next named bed, the Colvin Run limestone. This interval averages about 20 feet.

The Colvin Run limestone caps several of the hills in the trough of the Irwin syncline in the district one mile and a half to two miles southeast of Irwin. It undoubtedly must be present in some of the hills farther south but is poorly exposed. The limestone consists of several beds close together and attains a thickness of nine feet.

The following section was made at a quarry a quarter of a mile south of BM 1033 on the Lincoln Highway east of Irwin:

Section of Colvin Run limestone

	Ft.	in.
Shale, carbonaceous	1	
Limestone	1	8
Clay with many limestone nodules	3	
Limestone, yellow	4	6
Clay-shale, greenish-gray	3	6
Clay-shale with limestone nodules	2	
Limestone, gray	2	
Clay, gray	1	
Limestone, ferruginous		6

Waynesburg "A" coal. Fifteen to twenty feet below the Colvin Run limestone there is usually found a shaly thin coal, which has been given the name Waynesburg "A" since it corresponds to the coal of that name in other areas. It is habitually split, often shaly or bony and too thin ever to warrant mining even where it is good coal.

The Waynesburg "A", like the beds above it, is found only in the Irwin basin south of the Pennsylvania Railroad. Here it is quite persistently 60 to 70 feet above the Waynesburg coal.

This horizon is well exposed in a cut of the Herminie-Irwin trolley line at the top of the hill between Chambers and Lindencross (now Cereal). The section as exposed there is as follows:

Section ¼ mile north of Chambers

	Ft.	in.
Sandstone, greenish-yellow, shaly and massive	12+	
Shale, black	3	
Coal, Waynesburg "A"—upper split	1	
Clay, yellow	1	
Shale, black to brown	4	
Shale, black (bottom 6" bituminous)	6	
Limestone, soft, yellow, weathered	1+	
Clay		6
Limestone, hard, gray	1	10
Clay-shale		10
Limestone, hard, gray	1	8
Shale		

A quarter of a mile west the following section, illustrating the character of the rocks between the Waynesburg A and the Waynesburg coals, was measured:

Section ¼ mile northwest of Chambers

	Ft.	in.
Limestone boulders (Colvin Run)		
Sandstone	2+	
Shale and sandy shale	5	
Coal, shaly, Waynesburg "A" (upper division)		6
Clay, gray	3	
Limestone, gray, weathered yellow	1	10
Clay	3	
Limestone, gray		6
Clay with ferruginous limestone nodules	3	6
Shale	6	
Sandstone, massive, Waynesburg	30	

Other measured sections are as follows:

Quarry ¼ mile south of B. M. 1144 and slightly over a mile west of Adamsburg.

	Ft.	in.
Shale, brown	5	
Shale, black, carbonaceous	1	6
Coal, several thin clay partings, Waynesburg "A"	1	2
Clay, yellow	1+	
Limestone		

Section at top of hill one mile northwest of Rillton.

	Ft.	in.
Shale, black (Waynesburg "A" horizon)	1	
Clay, yellow	2	
Limestone, yellow, weathered	.	6+
Clay and concealed	5	
Limestone, brown-gray	1	8
Shale, brown	3+	
Concealed	10	
Waynesburg sandstone	8+	

Mount Morris limestone. The above sections also illustrate the usual character of the Mount Morris limestone and the average interval between it and the Waynesburg "A" coal bed above. It is never over six feet thick in this area, the average thickness probably being less than three feet. Where best developed it consists of three benches, a yellow, weathered limestone above and hard, gray limestone beds close beneath it. Although this limestone is not thick, it seems to be quite persistent and was found at practically every point where its horizon was exposed.

Waynesburg sandstone. The Waynesburg sandstone and associated shales, occupying the interval between the Mount Morris limestone and the Waynesburg coal, is, where typically developed, a massive, coarse-grained, thick-bedded deposit. It attains a thickness of 30 to 35 feet in the Irwin basin, and a slightly greater thickness in the Greensburg basin. Where it lies immediately above the Waynesburg coal and where it is massive and thick, it is easy to trace and aided in mapping the Waynesburg coal. This sandstone, like all other sandstones in this region, contains a large percentage of feldspar fragments and weathers to a light brown color. North of the main line of the Pennsylvania Railroad the Waynesburg sandstone is not so well developed as it is farther south, but it is always present in areas where this part of the stratigraphic section is exposed.

PITTSBURGH SERIES—MONONGAHELA GROUP.

The Pittsburgh series comprises that part of the stratigraphic section from the top of the Waynesburg coal to the base of the Brookville coal and includes the Monongahela, Conemaugh, and Allegheny groups. (See p. 17 and the Columnar Section).

The Monongahela group is characterized by limestone beds, which, in this quadrangle, comprise about one-third of the group. The thickness and character of the whole group vary considerably from place to place but in general there is a thickening towards the east. The average thickness in the Greensburg basin is about 400 feet. In the Irwin basin the average is about 370 feet. This is a greater thickness than is generally attributed to the Monongahela, but field work and drill-hole records confirm this figure.

As indicated in the following sections the Monongahela group changes greatly in character from place to place; this applies particularly to the limestone members, but the sandstones also vary greatly.

Composite of several sections measured near Herminie, Sewickley township.

	Thickness Ft.	Total Ft.
Coal, Waynesburg	3	3
Clay	3	
Shale, sandy	12	18
Shale	3	21
Concealed	7	28
Limestone, dark gray, and interbedded clay	6	34
Sandstone	2	36
Shale, sandy	6	42
Shale	15	57
Sandstone, shaly	6	63
Shale	7	70
Sandstone, thin-bedded	8	78
Limestone, cream-colored	8	86
Shale	5	91
Limestone beds, cream and gray,	15	106
Shale, gray	2	108
Limestone. thick beds separated by thin clay and shale beds	22	130
Shale, gray	3	133
Limestone, gray	5	138
Shale	6	164
Limestone, gray	4	168
Concealed	11	179
Limestone	5	184
Clay	4	188
Sandstone, compact, gray	5	193
Concealed	25	218
Limestone, gray	4	222
Clay, drab	2	224
Coal, shaly, "Bench"	1	225
Sandstone, hard, compact gray	6	231
Shale and sandy shale	8	239
Concealed	10	249
Limestone	7	256
Concealed	26	272
Sandstone, shaly	6	278
Sandstone, coarse-grained, massive bedded	10	288
Coal, Redstone	4	292
Clay with limestone nodules	10	302
Shale	25	327
Sandstone, thin-bedded	20	347
Shale, sandy	16	363
Coal and partings, Pittsburgh	9	372

Composite of three sections measured southwest of Irwin.

	Thickness Ft.	Thickness in.	Total Ft.	Total in.
Coal, Waynesburg	2	5	2	5
Clay	1		3	5
Shale, brown, soft	8		11	5
Coal, shale		6	11	11
Clay	3		14	11
Shale, sandy	7		21	11
Clay	2	6	24	5
Shale	4		28	5
Sandstone	3		31	5
Shale, sandy	5		36	5
Concealed	17		53	5
Limestone, gray, weathers yellow	4		57	5
Concealed	5		62	5
Sandstone, gray, thin-bedded	5		67	5
Concealed	5		72	5
Sandstone, greenish-yellow, thin-bedded	10		82	5
Concealed	27		109	5
Limestone, cream-colored	6		115	5
Concealed	4		119	5
Shale, greenish-gray to greenish-yellow	11		130	5
Limestone beds, gray and yellow	12		142	5
Concealed	17		159	5
Shale, greenish-yellow	3		162	5
Clay (partly concealed)	10		172	5
Limestone	6		178	5
Sandstone and shale, inter-bedded	12		190	5
Limestone	6		196	5
Shale, limy, "cement rock"	4		200	5
Limestone beds with some inter-bedded shale and clay	17		217	5
Concealed	12		229	5
Limestone	3		232	5
Clay, yellow	2		234	5
Concealed	6		240	5
Sandstone, thin-bedded	8		248	5
Shale	4		252	5
Coal and carbonaceous shale, "Bench"	2	6	254	11
Shale, yellow	4		258	11
Sandstone, gray, shaly	4		262	11
Shale	2		264	11
Limestone beds	10		274	11
Clay, olive-green	15		289	11
Limestone	2		291	11
Clay	2		293	11
Shale	5		298	11
Sandstone, yellow, massive-bedded, badly cross-bedded, Sewickley	20		318	11
Clay, gray, with many limestone nodules	3		321	11
Clay, yellow	2	6	324	5
Limestone, light-gray	1	8	326	1
Clay	4		330	1
Sandstone, hard, gray, close-grained	3		333	1
Shale, sandy, and occasional thin sandstone beds	40		373	1
Shale, dark gray	10		383	1
Coal and partings, Pittsburgh	9		392	1

Section measured along the Pennsylvania Railroad going east from Irwin.

Sandstone, Uniontown (?)	15		15	
Concealed	15		30	
Shale, sandy	9		39	
Sandstone	8		47	
Shale, sandy	9		56	
Sandstone	7		63	
Shale	8		71	
Limestone and inter-bedded thin clay and shale beds	35		106	
Clay	3		109	
Sandstone	5		114	
Shale, sandy	14		128	
Shale, carbonaceous		6	128	6
Shale, sandy	8		136	6

Section measured along the Pennsylvania Railroad going east from Irwin—Continued.

	Thickness		Total	
	Ft.	in.	Ft.	in.
Limestone	13		149	6
Shale	6		155	6
Coal, shaly, and carbonaceous shale	1	6	157	
Sandstone	11		168	
Shale, brown, sandy	10		178	
Limestone	15		193	
Clay	15		208	
Sandstone, coarse-grained, cross-bedded, Sewickley	30		238	
Clay-shale	1		239	
Shale, carbonaceous		2	239	2
Clay, drab	8		247	2
Limestone, compact, brittle, Redstone	1	10	249	
Shale and sandstone, inter-bedded	57		306	
Coal and partings Pittsburgh	9		315	

Section measured going south from Export.

Coal, Waynesburg	1		1	
Shale, brown	12		13	
Sandstone and sandy shale	18		31	
Shale and sandy shale	14		45	
Coal, shaly, Little Waynesburg		6	45	6
Sandstone, shaly	20		65	6
Sandstone	25		90	6
Shale, drab and carbonaceous	10		100	6
Limestone	5		105	6
Clay, drab	5		110	6
Limestone	10		120	6
Shale	3		123	6
Limestone	4		127	6
Clay	3		130	6
Shale	2		132	6
Limestone	9		141	6
Shale	3		144	6
Limestone	7		151	6
Shale, sandy	3		154	6
Sandstone	19		173	6
Shale	3		176	6
Limestone and inter-bedded shale	20		196	6
Clay	4		200	6
Shale	6		206	6
Sandstone, shaly, thin-bedded	11		217	6
Shale, carbonaceous	4		221	6
Sandstone	10		231	6
Shale	8		239	6
Limestone	11		250	6
Clay	5		255	6
Shale, sandy	15		270	6
Sandstone and sandy shale	18		288	6
Shale	7		295	6
Coal, shaly, Redstone		6	296	
Clay	4		300	
Shale	5		305	
Sandstone	18		323	
Shale	12		335	
Sandstone, massive-bedded, coarse-grained, Upper Pittsburgh	21		356	
Shale	6		362	
Coal, Pittsburgh	9		371	

Composite section for district one to three miles north of Greensburg.

Coal, Waynesburg	1		1	
Clay	4		5	
Shale, sandy	5		10	
Sandstone	6		16	
Clay-shale, gray	10		26	
Shale	5		31	
Coal, Little Waynesburg		10	31	10
Shale, sandy	5	2	37	
Sandstone	10		47	
Limestone	5		52	
Shale, sandy	10		62	
Sandstone	20		82	

Composite section for district one to three miles north of Greensburg—Continued.

	Thickness Ft.	Thickness in.	Total Ft.	Total in.
Shale, sandy	5		87	
Shale, black	10		97	
Shale, carbonaceous. Uniontown coal horizon	1		98	
Limestone and some inter-bedded clay and shale	14		112	
Sandstone, shaly	6		118	
Limestone and inter-bedded clay and shale	35		153	
Clay	3		156	
Sandstone, thin-bedded	7		163	
Shale, sandy	7		170	
Limestone	20		190	
Sandstone	3		193	
Shale, black, sandy	5		198	
Sandstone	8		206	
Shale, sandy and inter-bedded sandstone	55		261	
Shale, carbonaceous, Sewickley coal horizon	1		262	
Limestone	1		263	
Shale, sandy	15		278	
Sandstone	40		318	
Shale, sandy	20		338	
Clay	5		343	
Limestone, Redstone	1	4	344	4
Shale, gray		2	344	6
Shale, ferruginous, nodular	1	3	345	9
Shale, carbonaceous		5	346	2
Shale, calcareous		10	347	
Limestone	2	6	349	6
Shale	22		371	6
Sandstone	23		394	6
Shale	4		398	6
Coal, Pittsburgh	9		407	6

The Monongahela group is confined largely to the Irwin syncline, its continuation the Elders Ridge syncline, and the Greensburg syncline. Small patches of the lower part of the formation occur in the northwest part of the quadrangle where the rocks have been downfolded by the Duquesne syncline.

Waynesburg coal. The Waynesburg coal, the top member of this formation, is a persistent coal of variable composition and thickness which outcrops around the hills in the Irwin syncline and the tops of of the higher hills in the Greensburg syncline. It is a dirty coal, high in ash and sulphur and often contains thick clay partings. It ranges in thickness from over five feet in the southwestern part of the quadrangle to less than 15 inches in some of the northern outcrops.

Section showing Waynesburg coal 1½ miles south of Export.

	Feet
Wash	3+
Limestone, brown	1
Limestone, dark gray, Mount Morris	1
Shale, calcareous	5
Sandstone	20
Sandstone, thin, and brown sandy shale	14
Coal, Waynesburg	1
Shale	12
Sandstone	30
Clay	1+

Section 1 mile west of Harrison City.

	Feet
Shale, sandy	10+
Coal (Waynesburg) and bituminous shale	4
Limestone, cream color, fragments and concealed	2
Sandy shale	20+

Section 1 mile south of Circleville.

	Ft.	in.
Sandstone and shaly sandstone	10+	
Coal, Waynesburg	2	5
Clay		6
Shale, brown and thin sandstone	10	
Coal, boney		6
Clay, stained by iron	4	
Sandstone, thin micaceous, and shale	6	
Clay	3	
Coal, Little Waynesburg		4
Shale, brown		

Section ½ mile southeast of Herminie.

Sandstone, massive	10+	
Coal	1	
Clay	1	3
Coal	2	7
Clay	1	5
Coal	2	
Clay		3+

Section 2½ miles northeast of Greensburg.

Sandstone, massive	35+
Concealed (shale?)	5
Coal, Waynesburg	1
Concealed	

Little Waynesburg coal. A sandy shale usually is found between the Waynesburg coal and the next coal beneath it, the Little Waynesburg. In other areas this interval in occupied by the Brownstown sandstone. The sandstone in this quadrangle is seldom very well developed. Where present it is arkosic (which means it contains many feldspar fragments mixed with the quartz grains) and weathers easily. It does not form a prominent bench as some of the harder and more resistent sandstones do.

The interval between the Waynesburg and Little Waynesburg coals varies considerably, ranging from 16 to 35 feet. The Little Waynesburg is never of workable thickness but being close to the Waynesburg coal was often recognized.

Where freshly exposed, as in the railroad cut south of Lindencross (Cereal), the coal appears to be of fairly good quality. As usually observed it is badly weathered and shaly. The following sections indicate its average occurrence and character.

Section at north end of railroad tunnel between Lindencross and Chambers.

		Ft.	in.
Sandstone		10+	
Bone coal	Waynesburg		1
Clay	Waynesburg		10
Coal	Waynesburg	1	2
Bone coal	Waynesburg		9
Coal	Waynesburg	1	
Clay, gray		4	
Sandstone, yellow		2	
Shale, gray		10	
Coal, Little Waynesburg			5
Clay, sandy		3	
Sandstone, yellow, micaceous, coarse grained		1	8
Shale, brown			

Section 1 mile southwest of Rillton.

	Ft.	in.
Sandstone	5+	
Coal, Little Waynesburg		7½
Shale, brown and sandy shale	12	
Coal, thin streak		
Limestone, hard, dark gray		10
Clay	1	
Limestone, yellow, weathered	1	3
Clay, yellow	2	6
Limestone, weathered, yellow	2	
Clay		

Waynesburg limestone. From 1 to 15 feet below the Little Waynesburg coal is a limestone which in other areas attains a thickness of over 25 feet, and which has been called the Waynesburg limestone. In this quadrangle it seldom is more than five feet thick. Few good exposures of it were seen and it is not believed to be persistent over large areas. It usually consists of two or three beds of fresh-water limestone separated by soft clay. The limestone beds vary in color from gray to yellow depending on the extent to which they are weathered. The following section illustrates about the maximum development of the Waynesburg limestone in this region.

Section ½ mile southeast of Herminie.

	Ft.	in.
Shale, brown	3+	
Limestone, dark gray, shaly at top	1	
Clay-shale, dark	3	6
Limestone, light gray, massive	3	
Sandstone, thin, hard beds and brown shale	12+	

Uniontown sandstone. Five feet or more beneath the Waynesburg limestone is a hard, fine-grained, thin-bedded sandstone which is very resistent to weathering and which often forms a prominent break in the hill slopes where it occurs. This sandstone has been called the Uniontown sandstone because it occurs at the same horizon as the sandstone of that name at Uniontown. Ordinarily it is not over ten feet thick and often it is represented by sandy shale or shale.

Uniontown coal. A thin, carbonaceous shale or bony coal occurring close beneath the Uniontown sandstone has been given the name Uniontown coal although at few places in this area is it good coal. In the Irwin basin this bed occurs from 260 to 280 feet above the Pittsburgh coal, and about 110 feet below the Waynesburg coal. Towards the north and the west it is either entirely missing in the section or else represented by a thin, carbonaceous shale. The following section was measured one mile southwest of Herminie, where the greatest thickness was seen.

Section 1 mile southwest of Herminie.

	Ft.	in.
Sandstone, thin bedded, fine-grained	20+	
Concealed (partly brown shale)	5	
Coal, Uniontown (upper split)		6
Clay, gray	1	6
Shale, brown	5	6
Coal, Uniontown	1	3
Shale, brown	1	
Concealed (limestone and sandstone boulders)	5	
Limestone, hard, gray, compact (2 beds)	4+	

Benwood limestone. Directly beneath the Uniontown coal, or separated from it by only a few feet of shale, is a limestone bed, the uppermost of many limestone beds which for the sake of convenience have all been grouped together and called Benwood limestone. By this term we designate all those beds between the Sewickley sandstone (or Sewickley coal when present) and the Uniontown coal. This in places represents a total thickness of 170 feet of limestone, shale, sandstone, and clay. Usually the limestone beds are in two groups separated by shále and sandstone. The upper group of limestone beds has received the name Uniontown limestone. Due to the fact that the limestone beds weather more easily than some of the rocks above and below, it was found impossible to obtain a complete section. Such sections as were obtained seem to indicate much variation in the various beds, both in thickness and distinguishing characteristics.

As shown in the accompanying sections the two groups of limestone beds in the Benwood are not massive, thick limestone, but consist rather of many individual beds, separated by shale or clay. Well drillers invariably report the Benwood as one, or possibly two, massive limestone beds, 30 or more feet thick. This has tended to give a rather erroneous impression of the true character of the Benwood.

Section of upper part of Benwood limestone as exposed in railroad cut at Herminie.

	Ft.	in.
Wash	5+	
Limestone, cream gray		10
Shale, drab	1	
Limestone, massive, gray, weathered cream color	2	6
Shale, gray paper	6	
Limestone, massive	2	3
Clay shale	1	
Limestone, cream gray	1	6
Clay shale		6
Limestone, cream gray	1	3
Clay shale		3
Limestone, cream gray	2	7
Shale, soft		6
Limestone, cream gray	1	10
Shale, soft	1	
Limestone	2	3

Section along road and stream bed one-third mile northwest of Herminie.

	Ft.	in.
Sandstone, shaly, gray	1	6
Shale, brown, to clay-shale	2	
Shale, bituminous (Uniontown coal horizon)		4
Clay, brown	1	
Limestone, cream color (2 beds)	4	
Concealed	4	
Limestone, light to dark gray (3 beds)	6	
Shale, gray	5	5
Limestone, yellow (several beds)	4	
Limestone, hard, rusty stained	1	
Limestone beds, gray to cream gray	4	
Clay	2	
Limestone, dark gray		6
Concealed	2	
Limestone, gray	2	6

Section of upper part of Benwood limestone in a cut of the Youghiogheny branch of the P. R. R. ¾ mile southwest of Rillton.

	Ft.	in.
Sandstone, thin-bedded	5+	
Limestone, dark gray shaly (top of Benwood)		10
Limestone, light gray to cream gray	5	
Shale, gray to clay-shale	5	
Limestone, massive, cream color beds	4	
Shale, gray to brown	3	6
Limestone, soft, yellow	2	3
Shale	1	
Limestone, gray to cream color	12	
Shale, greenish-gray	3+	

Section of lower part of Benwood limestone in southwest corner of quadrangle.

	Ft.	in.
Shale, gray and interbedded sandstone	12	
Limestone, dark gray, impure	1	8
Limestone, cream colored (several beds)	18	
Clay	4	
Shale, gray, sandy at top	18	
Sandstone, massive	2	
Shale, drab, sandy	16	
Shale, dark	4	
Coal, Redstone	2	6
Clay with limestone nodules	11	

Section of Benwood limestone in first and second cuts east of Greensburg along the P. R. R. tracks.

	Ft.	in.
Shale, fissile, weathered brown	14	
Limestone, soft, easily weathered, fossiliferous (fresh water)	8	
Limestone, massive, gray, weathers buff	2	
Limestone, shaly	4	
Shale, dark blue-gray fissile	7	6
Limestone, massive, gray, weathering buff	15	
Limestone, massive, and dark gray shale	7	
Shale, limy	1	
Limestone, weathered deep buff	4	
Clay	2	6
Fireclay, dark gray		4
Shale, sandy, and shaly sandstone	5	
Shale, dark, slate-color, fissile, gritty	6	
Limestone, compact, buff and gray	13	
Concealed	23	
Sandstone, massive, thick-bedded, micaceous, rusty brown, light gray on fresh fracture	66	

Section along road from Manor south to Lincoln Highway.

	Ft.	in.
Coal, Waynesburg		
Sandstone, buff colored fine grained	28	
Concealed	27	
Sandstone, coarse grained	10	
Sandstone, shaly	10	
Concealed	10	
Limestone	5	
Shale, sandy	4	6
Limestone (many beds)	30	
Concealed	15	
Limestone (several beds)	15	

Section south of Harrison City.

	Ft.	in.
Shale, carbonaceous. Uniontown coal horizon	3	
Limestone, dark gray, carbonaceous		6
Clay	8	
Limestone, blue-gray	1	9
Clay		11
Limestone, dark gray		6
Clay		5
Limestone, mottled gray	1	6
Limestone, badly weathered	1	8
Concealed	6	
Limestone, yellow		8
Concealed (limestone boulders)	24	
Sandstone, greenish-yellow, micaceous	2	6
Concealed	7	6
Limestone, compact, hard	2	6
Concealed	7	6
Sandstone, greenish-gray, ripple marks near top	15	
Concealed	4	
Limestone, hard, compact		8
Concealed	5	
Limestone (several beds)	10	
Concealed	5	
Limestone, dark bluish-gray		10
Clay, drab	5+	

The various limestone beds in the Benwood group vary from pure, blue gray limestone to dark gray, carbonaceous and soft, arenaceous limestone. Much of it is good enough to burn for lime and farmers have used it extensively for this purpose. At one or two points small fresh water fossil shells were observed.

The Benwood limestone crops out over a large area in this quadrangle in both the Irwin and Greensburg synclines (See fig. 24).

Distance between base of Benwood limestone and base of Pittsburgh coal.

Location	Feet
Southwest corner of quadrangle	117
East of Irwin along P. R. R. tracks	125
Southwest of Harrison City	120
Lincoln Highway, Radebaugh to Greensburg	160
Northwest of Boquet	190
1 mile north of Hannastown	150

Towards the north the Pittsburgh and Sewickley sandstones seem to thicken and the Benwood limestone becomes thinner so that the interval between it and the Pittsburgh coal increases from south to north.

"Bench" sandstone. The so-called "bench" sandstone in the Benwood member (so named because of the manner in which this sandstone often forms a prominent break or bench in the slope) is a hard, fine-grained, thin-bedded, micaceous sandstone which resists weathering well and which was used in the field as a key rock by which to map the softer and more easily weathered Benwood limestone. In the Irwin basin this sandstone is 20 to 30 feet thick, and is quarried locally for road metal and foundations. Shales are usually associated with this sandstone.

"Bench coal." In the Irwin basin a thin coal containing many partings was noted in this "bench" sandstone. At only one point was a thickness of over 18 inches observed. This was near the road fork half a mile west of Edna No. 1. A drift driven in about 50 feet from the crop at this point, showed the coal to be of variable thickness and character. The following section was obtained in the face of the entry:

Section ½ mile west of Edna No. 1 Mine.

	Ft.	in.
Shale		
Clay	3	
Coal		5½
Clay		4
Coal		5½
Clay		2½
Coal	1	1
Clay	2+	

A more typical section of this coal bed was obtained immediately behind the Irwin high school.

Section at Irwin high school.

	Ft.	in.
Clay, gray to brown	1+	
Shale, carbonaceous	1	
Coal, bony		6
Coal	1	
Shale, greenish-yellow	4	
Shale, black,		4
Sandstone, gray, shaly, sericitic	4+	

The interval to the base of the Pittsburgh coal at this point is 138 feet. At the country bank half a mile west of Edna No. 1 the interval is 142 feet.

Sewickley sandstone. The Sewickley sandstone, underlying the the Benwood limestone, in many places is a massive, coarse-grained deposit forming a marked feature of the topography. In some places it is composed of interbedded sandstone and shale and is easily weathered. It is well exposed in the railroad cut just to the east of Irwin where it is massive bedded, and about 32 feet thick. The manner in which the shale directly underlying the sandstone has been folded and contorted suggests that the shale had already been fairly well compacted when the sandstone was laid down. This feature, an unconformity, was frequently observed at the base of massive sandstones. In the aforementioned cut the sandstone is underlain by clay, by carbonaceous shale (the horizon of the Redstone coal) and by greenish-gray shale. The unconformity is quite noticeable.

Near Greensburg this sandstone is even more massive. It is also more evenly bedded and hence suitable for quarrying. The thickness, as measured in a quarry inside the city limits, is over 60

feet. Near Export it is about 42 feet thick and east of Sardis over 30 feet. In the southern part of the quadrangle the sandstone is more apt to be interbedded with shale.

Half a mile west of Penn Station the Pennsylvania Railroad has made a deep cut through a projecting hill to shorten its line. The following section was made there:

Section ½ mile west of Penn Station.

	Feet
Sandstone, massive, Sewickley	55
Limestone, Redstone	0 to 7
Sandstone	8+

As at Irwin the base of the Sewickley sandstone lies unconformably on the strata below. The Redstone coal, which occurs both north and south of the railroad, has been entirely eroded and the Redstone limestone which lies beneath the coal, has been partially eroded. Inasmuch as some seven feet of limestone is cut out entirely in places, it seems probable that the region either was raised several hundred feet and that erosion was quite rapid, or else that this represents a former stream channel. From the fact that such erosional unconformities were commonly noted at the base of massive sandstones, it is believed that the first supposition represents the true condition and that subsidence of the floor of the great Appalachian trough was so rapid that erosion was not able to cut down the surface to a peneplain before the waters of the inland sea again flowed over the land and deposition was begun again.

In the same cut it is possible to observe a repetition of the above process in the sandstone itself. In places the sandstone has been cut out and replaced with sandy shale. This unconformity is not so noticeable as the one lower down.

Sewickley coal. The Sewickley coal, 25 to 60 feet above the Redstone coal, occurs persistently only in the vicinity of Greensburg. The maximum thickness noted is within the city limits.

Section of Sewickley coal ¼ mile south of Greensburg City Hall.

	Ft.	in.
Sandstone	3+	
Bituminous shale		4
Coal	1	4½
Shale		2
Coal, bony		2
Shale, carbonaceous		6
Coal, bony		4
Shale		5

At other points the coal measures less than 18 inches. The coal is usually underlain and overlain by sandy shale and sandstone. Sometimes a thin, shaly coal occurs 15 to 25 feet beneath the main bed. A typical section can be seen along the main line of the Pennsylvania Railroad about 1½ miles east of Greensburg station.

Fishpot limestone. Just south of Carbon the Fishpot limestone occurs in the interval between the Sewickley and Redstone coals. Although the limestone is there twelve feet thick, it thins rapidly in every direction, and this is the only locality in the quadrangle where it is more than two or three feet thick. The following section was measured where the road running south from Carbon passes over the tracks of the Pennsylvania Railroad cut-off:

Section at Carbon.

	Ft.	in.
Shale, brown	12	
Shale, carbonaceous (Sewickley coal horizon)	1	8
Limestone	5	6
Clay, ferruginous	2	
Shale	1	
Limestone, very massive	3	6
Limestone, soft, yellow	3	
Clay		6
Concealed	9	
Coal, Redstone	2+	

Redstone coal. The Redstone coal underlies the Sewickley sandstone and is found at an average interval of 75 feet above the base of the Pittsburgh coal. It is the second most valuable coal in the quadrangle and has been mined to a greater extent than any other coal save the Pittsburgh. Where well developed it is a bright, hard, blocky coal, fairly low in sulphur and ash. Unfortunately it is frequently cut by clay and sandstone horses. Binders are usually thin and unimportant.

The Redstone coal thins rapidly from south to north. The maximum thickness observed was at a point about one mile south-southeast of Madison Station and only one-quarter of a mile north of the southern boundary of the quadrangle.

Section 1 mile south-southeast of Madison Station.

	Ft.	in.
Sandstone, massive, cross-bedded	5+	
Shale and carbonaceous shale	1	3
Coal, Redstone	2	5
Clay		3
Coal, Redstone	4	1
Clay	1+	

At Darragh (now New Madison), the coal exposed at the intersection of the two main roads, is over 3½ feet thick and capped by a massive sandstone.

The superintendent of the Edward Tomajko mine is authority for the statement that the thickness shown in the following section is several inches greater than the average for that area.

Section ¼ mile northwest of Edna No. 1.

	Ft.	in.
Shale	10+	
Coal, Redstone	4	11
Clay	1+	

West of Penn Station the Redstone coal is in part cut out by the overlying Sewickley sandstone but it comes in again to the north and has been opened up by a farmer at a point about two-thirds of a mile north of Penn Station. At this opening the coal measured 30 inches. North of this point no openings were seen in the Redstone coal.

Similarly in the Greensburg basin, the coal is fairly thick south of the railroad but pinches down rapidly towards the north.

The following sections illustrate the character of the coal in different areas:

Section in southwest corner of quadrangle.

	Feet
Shale, brown	2+
Clay	3
Coal, Redstone	4
Clay	1+

Section in Coal Run just north of Irwin.

	Ft.	in.
Sandstone		
Coal, shaly	2	
Clay, yellow, sandy	1+	

Section ½ mile northwest of Paintertown.

	Ft.	in.
Shale, sandy		
Coal, Redstone	1	
Fire clay		6+

Section ¾ mile southwest of Export.

	Ft.	in.
Sandstone and sandy shale		
Coal, Redstone		8
Clay	5	±
Sandstone		

Section at Sloan, Salem Township.

	Ft.	in.
Sandstone, thin bedded micaceous	10+	
Shale, sandy	5	
Coal, Redstone		7
Fire clay		6
Sandstone, soft, olive, shaly, with iron nodules	10	
Sandstone, thin bedded	4	
Sandstone, thick bedded	20+	

Section at east end of tunnel at Radebaugh.

	Ft.	in.
Shale	4	
Sandstone	12	
Coal, Redstone	2	
Shale	1	
Sandstone, shaly	21	
Sandstone, coarse-grained	6	

Section 1½ miles east of Greensburg at B M 1257.

	Ft.	in.
Sandstone, shaly	20	
Coal, Redstone		10
Clay shales, light gray		6
Limestone, massive, gray	3	

Section at Huff, Keystone Clay Products Co. mine.

	Ft.	in.
Shale, dark gray	16	
Fire clay, gritty	2	
Shale, black, coaly		4
Coal, Redstone	4	4
Fire-clay, light gray	2	
Limestone	12	
Clay-shale	3	
Shales, sandy	20	

In the northwest corner of the quadrangle, the Redstone limestone was noted in the tops of some of the hills but no coal was seen above it.

Distance between base of Pittsburgh coal and Redstone coal.

Location of section	Feet.
1 mile south southeast of Madison Station	77
Darragh (New Madison)	85
¼ mile northwest of Edna No. 1 Mine	80
Southwest corner of quadrangle	78
Coal Run, north of Irwin	80
½ mile northwest of Paintertown	70
¾ mile southwest of Export	75
Sloan, Salem Township	65
East end of tunnel at Radebaugh	85
1½ miles east of Greensburg, B. M. 1257	95
Huff	80
1 mile south of Irwin Station	61
Penn Station	66

It will be seen from the above figures that the interval from the Pittsburg coal to the Redstone is fairly constant over much of the quadrangle.

Redstone limestone. The Redstone limestone, occuring close beneath the Redstone coal, is a rather persistent, fresh-water, compact, brittle limestone which increases in thickness and importance from west to east.

Where it is thick, and in all regions where the Redstone coal is missing but the limestone present, the latter is usually pure and compact, breaks with a smooth conchoidal fracture, and is often characterized by small, sparkling calcite crystals on the broken rock.

In the Irwin basin where the Redstone coal is thick, the Redstone limestone is thin or missing; and where the coal thins out towards the north, the limestone becomes more prominent. Thus, in the southwest corner of the quadrangle we find 3½ to 4 feet of coal and only scattered limestone nodules in the clay beneath it; whereas at Irwin, where the coal is thin and sometimes only represented by a thin, carbonaceous shale, the limestone measures from one to two feet.

A section of the Redstone horizon (the coal has been cut out by the Sewickley sandstone above) was measured at an exposure near the western edge of the town of Irwin.

Section at west edge of Irwin.

	Ft.	in.
Sandstone, massive, cross-bedded, medium grained, unconformity at base	20+	
Clay, gray with limestone nodules	3	
Clay, yellow limy	2	6
Limestone, light gray, smooth fracture, Redstone	1	8
Clay with limestone nodules—grades into shale at base	4	
Sandstone, thin, hard, gray, close-grained	1	6
Shale, gray to greenish-gray, sandy	6+	

Near Penn Station the Redstone limestone varies from zero to eight or ten feet thick, depending on whether or not erosion cut it down before the deposition of the Sewickley sandstone. Near Greensburg it attains its maximum development in this quadrangle.

Section 1½ miles east of Greensburg.

	Ft.	in.
Wash	2	
Limestone, much jointed, conchoidal fracture	1	
Shale, limy, and clay	2	6
Clay-shale with bluish-gray fire clay parting		6
Clay, rusty, limy	1	
Limestone, massive, conglomeritic, weathers rusty	4	6
Limestone, soft, weathered		6+

(See also section at Huff on page 34)

Pittsburgh rider coal. This coal, found approximately half-way between the Pittsburgh coal and the Redstone limestone, was noted at only a few points in the Irwin and Greensburg synclines. It is seldom good, clean coal in this quadrangle. Rather, it is characteristically shaly or bony. Many years ago several small openings were made in this coal in the vicinity of Greensburg, but these openings have since fallen in and are now hardly discernible.

In the Irwin basin this rider coal is about 30 feet above the base of the Pittsburgh coal at a point one mile north of Export.

Section 1 mile north of Export.

	Ft.	in.
Sandstone, coarse-grained, greenish-brown, thin-bedded	35+	
Shale, carbonaceous, Redstone horizon (coal on opposite side of hill		10
Concealed	12	
Shale, sandy and limestone float (Redstone)	15	
Sandstone, gray, sandy, micaceous	20	
Shale, carbonaceous and fire clay	1	
Coal, shaly and carbonaceous shale	3	
Sandstone, thin-bedded, shaly	3	
Interval to base of Pittsburgh coal	27	

One mile southwest of Greensburg on the Mt. Pleasant road it occurs 35 feet above the base of the Pittsburgh coal. There it is 16 inches thick with dark shale both above and beneath it.

The "rider" coal is well exposed in the railroad cut at Radebaugh.

Section at Radebaugh.

	Ft.	in.
Sandy shale soil	3	6
Coal, Redstone	2	
Fireclay	1	6
Concealed	2	
Limestone, gray, weathering white; nodular	1	6
Clay / Shale, sandy, weathered buff	22	
Coal, shaly, Pittsburgh Rider		8
Shale, dark gray, fissile, sandy	11	
Sandstone, Upper Pittsburgh	12	
Shale, dark	6	
Coal, Pittsburgh (upper and lower division)	13	4
Clay-shale, soft, gray	1	6

It was also noted in drill holes in different parts of the Irwin and Greensburg synclines at intervals varying from 16 to 35 feet above the base of the Pittsburgh coal.

In some places directly above the Pittsburgh coal, but usually separated from it by five to ten feet of dark shale, is a thin bedded sandstone, which has been called Upper Pittsburgh sandstone. In this quadrangle it is seldom over 20 feet thick and is more often a sandy shale with sandstone lentils than it is a massive sandstone. It is well exposed in the first cut of the Pennsylvania Railroad west of Irwin.

Pittsburgh coal. The Pittsburgh coal bed, constituting the basal member of the Monongahela group, is by far the most important member of any group exposed in this quadrangle. More wealth has been derived from it in the past than from all the other rocks put together. The value of the Pittsburgh coal still remaining in the quadrangle after years of mining is a figure running into many millions of dollars.

A marked feature of this coal bed is its uniformity of section. This uniformity is illustrated in Fig. 2 in which are shown six sections measured at widely separated points in the quadrangle.

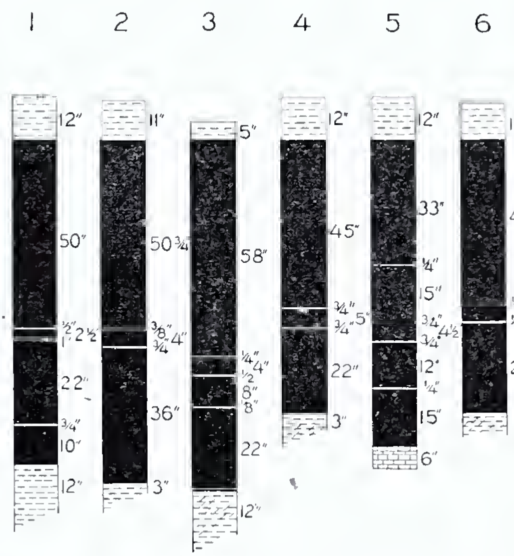


Fig. 2 Representative sections of the Pittsburgh coal in the Greensburg quadrangle.

The great value of this coal is due not only to its uniformity, but also to its continuity, its accessibility, and its chemical and physical characters. The wonderful continuity of the Pittsburgh coal, extending unbroken (except where eroded) for mile after mile, is well known. Fig. 3 shows the total areal extent of this bed in Pennsylvania, together with the relative location of the Greensburg quadrangle.

The outcrop and areal extent of the Pittsburgh coal in this quadrangle are shown on Plate V. The outcrop has been made to conform with the topographic mapping although the latter was found inaccurate at several points in the quadrangle.

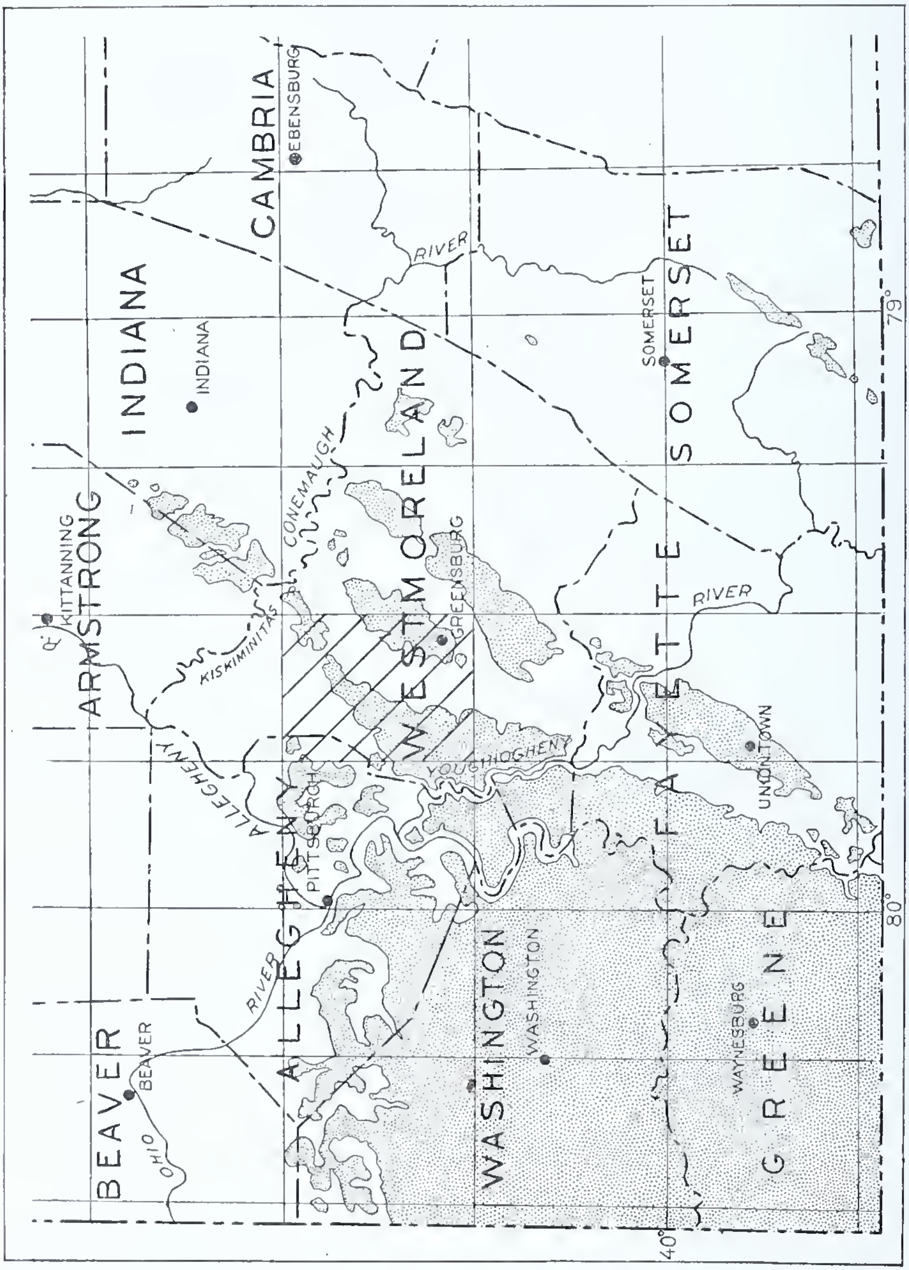


Fig. 3. Area underlain by the Pittsburgh coal bed in Pennsylvania and the location of the Greensburg quadrangle with reference to it.

The extended outcrop, comparatively flat dips, excellent railroad transportation, and shallow depths to the coal in the different synlines, constituted such ideal conditions for mining that this region was among the first of the bituminous fields to be exploited. The Westmoreland Coal Company, the Keystone Coal and Coke Company,

the Greensburg Coal Company, the Hillman Coal and Coke Company, and the Ocean Coal Company are only a few of the large corporations which have been mining the coal in this region for years.

The description of the chemical and physical characters of this coal will be found in the chapter on Mineral Resources.

CONEMAUGH GROUP.

The Conemaugh group extends from the base of the Pittsburgh coal down to the top of the Upper Freeport coal. Called the "Lower Barren Series" by the Second Pennsylvania Geological Survey on account of the thinness and poor quality of the coals contained in the formation, it seems fully to warrant such a designation in much of the territory in which it is exposed. The majority of the coals contained in the formation are of local occurrence only, and just two of them are thick enough to warrant being worked in this region at the present time.

The Conemaugh is the outcropping group over considerably more than one-half of the total area of the quadrangle. (See Plate V). It constitutes the surface rock over all three of the major anticlines and also the flanks of the synclines in the north. Predominantly shaly, in some areas sandstone replaces much of the shale. Certain horizons are characteristically shaly while others are apt to be sandy. These horizons have been given definite names. The limestones are mostly thin and local in their occurrence although one or two extend over wide areas. The Ames limestone, the highest (stratigraphically) marine limestone in the Carboniferous, has the widest distribution and its outcrop was mapped over the entire quadrangle. It proved a very useful "key" rock, and was used as a base in mapping much of the structure.

Both the thickness and character of the Conemaugh vary considerably from point to point. Its character changes so rapidly within short distances that no two sections of the Conemaugh look alike. Although given an average thickness of 660 feet, the thickness ranges from a minimum of 630 feet in the northwest, to a maximum of slightly over 700 feet in the southeast. The following sections are given in detail to illustrate the variable character of this group.

Partial record of diamond drill bore-hole near Rillton, Sewickley township.

	Thickness Ft.	in.	Total Ft.	in.
Pittsburgh coal			0	
Fire clay	4		4	
Shale, light-colored	10		14	
Limestone	6		20	
Shale, gray	3		23	
" light-colored	10		33	
Limestone	5		38	
Shale, light-colored	20		58	

Partial record of diamond drill bore-hole near Rillton, Sewickley township.—Continued.

	Thickness Ft.	in.	Total Ft.	in.
Sandstone	4		62	
Shale, light-colored	5		67	
Slate, black	4		71	
Bone	1		72	
Fire clay	2		74	
Limestone	4		78	
Shale, light-colored	18		96	
" gray	15		111	
Limestone	6		117	
Shale, light-colored	9		126	
" red	48		174	
" light-colored	11		185	
Sandstone	2		187	
Shale, light-colored	12		199	
" gray	8		207	
" light-colored	5		212	
" red	7		219	
" light-colored	2		221	
" red	19		240	
" light-colored	2		242	
" red	2		244	
" light-colored, sandy	20		264	
Slate, black	14		278	
Bone (Duquesne coal horiz.)		7	278	7
Shale, light-colored	10		288	7
" red	7		295	7
" light-colored (Ames horizon)	15	5	311	
" red	23		334	
" light-colored, sandy	22		356	
" red	3		359	
" light-colored	7		366	
" red	16		382	
" light-colored, sandy	31		413	
" variegated	5		418	
" gray	7		425	
" red	3		428	
" light-colored	1		429	
" red	15		444	
" light-colored, sandy	38		482	
Slate, black	2		484	
Limestone, Pine Creek	3		487	
Slate, black	4	6	491	6
Bone		6	492	
Shale, gray	2		494	
Sandstone, Buffalo	31		525	
Shale, dark, sandy	9		534	
Slate, black	18	6	552	6
Coal, Brush Creek		6	553	
Fire clay	16		569	
Shale, light-colored, sandy	18		587	
" light-colored	10		597	
Sandstone	8	6	605	6
Shale, dark	9	4	614	10
Bone (Mahoning coal horiz.)		2	615	
Shale, light-colored, sandy	13		628	
" dark, sandy	26	4	654	4
Coal, Upper Freeport				

Partial record of diamond drill bore-hole near Irwin.

	Ft.	in.	Ft.	in.
Interval from top of hole to base of Pittsburgh coal	28		28	
Surface wash	17	6	45	6
Shale, sandy	14		59	6
Shale, red, and slate	17		76	6
" red	13	6	90	
" red and black	13		103	
" light-colored	35	9	138	9
" red	34		172	9
" light-colored	30		202	9
" dark	6		208	
Coal, Wellersburg	4		209	1
Fire clay	15		224	1

Partial record of diamond drill bore-hole near Irwin.—Continued.

	Thickness Ft.	in.	Total Ft.	in.
Shale, light-colored	4	8	228	9
" red	22		250	9
" light-colored, sandy	31		281	9
Slate, black	2		283	9
Coal, Duquesne		9	284	6
Shale, light-colored	30		314	6
" dark	8		322	6
Coal, Harlem	1		323	6
Fire clay	8		331	6
Shale, light-colored	11		342	6
" red	10	6	353	
" light-colored	55	6	408	6
" dark	8		416	6
" light-colored	9		425	6
" red	6		431	6
" light-colored, sandy	39	6	471	
" dark	4	6	475	6
Fire clay	3		478	6
Sandstone	48	9	527	3
Shale, dark	13		540	3
Coal, Brush Creek		4	540	7
Clay, limy	10		550	7
Shale, limy	8		558	7
" light-colored, sandy	11		569	7
" light-colored, sandy	22		591	7
" dark, sandy	13	6	605	1
Coal, Mahoning		3	605	4
Fire clay	6		611	4
Clay, impure	13	7	624	11
Shale, light-colored, sandy	15	1	640	
" dark	3		643	
Slate	3		646	
Clay	3	11	649	11
Shale, sandy	8		657	11
Upper Freeport coal horizon				

Partial record of diamond drill bore-hole at Biddle, North Huntingdon township, Pa.

Pittsburgh coal			0	
Limestone, shaly	1	8	1	8
Limestone	1	4	3	0
Shale, light-colored, sandy	5	2	8	2
" light-colored	2	1	10	3
Limestone	4		14	3
Shale, light-colored	2	6	16	9
Limestone	4	6	21	3
Shale, light colored	7	6	28	9
Limestone	6		34	9
Limestone shaly	5	3	40	
Shale, red	2		42	
" light-colored, sandy	10	8	52	8
" sandy	24	8	77	4
" dark, sandy	39	9	117	1
" light-colored, sandy	17		134	1
" light-colored	5	6	139	7
" red	37	4	176	11
" light-colored, sandy	8	7	185	6
" red	1	2	186	8
" light-colored, sandy	12	2	198	10
" red	7	9	206	7
" light-colored	15		221	7
" red	20	2	241	9
" light-colored	8	3	250	
" sandy	18		268	
" light-colored	9		277	
" dark	9		286	
Slate, dark	9	6	295	6
Shale, limy	3	2	298	8
" light-colored	13	6	312	2
" dark gray	11	7	323	9
" limy (Ames horizon)	4	5	328	2

Partial record of diamond drill bore-hole at Biddle, North Huntingdon township, Pa.—Continued.

	Thickness Ft.	in.	Total Ft.	in.
Bone (Harlem coal horizon)		9	328	11
Shale, gray, limy	10		338	11
" red	9	4	348	3
" limy	10	9	359	
" dark green	2	9	361	9
" light-colored sandy	6		367	9
" light-colored	1	2	368	11
" red	7	4	376	3
" light green	18		394	2
" light-colored, sandy	8	10	403	1
" light-colored	5	6	408	7
" gray	26	4	434	11
" light-colored	6	3	441	2
" red	4	11	446	1
" light-colored, sandy	35	3	481	4
" gray	6		487	4
" light-colored, sandy	8		495	4
Sandstone, Buffalo	25	7	520	11
Shale, gray	4		524	11
" dark	8	3	533	2
Slate, black	16	7	549	9
Coal, Brush Creek		10	550	7
Fire clay	9	10	560	5
Shale, light-colored	2	6	562	11
" light-colored, sandy	9	10	572	9
" gray	8		580	9
Sandstone	3	6	584	3
Shale, light-colored, sandy	15	11	600	2
" dark	23	3	623	5
Bone coal (Mahoning)		4	623	9
Fire clay	8	10	632	7
Shale, light-colored, sandy	19	8	652	3
Sandstone	19	9	672	
Slate, black		2	672	2
Shale, gray	3	10	676	
Upper Freeport coal horizon				

Section along the Pennsylvania Railroad, Irwin to western boundary of quadrangle.

Pittsburgh coal			0	
Clay-shale, limy	1	9	1	9
Limestone	1		2	9
Clay	1		3	9
Limestone	1		4	9
Shale, limy	2		6	9
" drab, sandy	4		10	9
" gray, sandy	1	6	12	3
Sandstone, shaly, gray, micaceous	11		23	3
Fire clay		3	23	6
Shale, carbonaceous		2	23	8
Limestone, gray	1	3	24	11
Shale, carbonaceous		2	25	1
Clay-shale	1		26	1
Fire clay		6	26	7
Shale, drab-green	10		36	7
Limestone, compact	4	7	41	2
Clay	6		47	2
Concealed	10		57	2
Sandstone, shaly	20		77	2
Clay	3		80	2
Limestone	1		81	2
Clay	3		84	2
Shale	7		91	2
Clay	7		98	2
Shale	15		113	2
Limestone		10	114	
Sandstone, coarse-grained	10		124	
Shale, sandy	3		127	
Concealed	10		137	
Shale, sandy, and some interbedded sandstone	30		167	
" red	15		182	
Sandstone and sandy shale	20		202	

Section along the Pennsylvania Railroad, Irwin to western boundary of quadrangle.—Continued.

	Thickness Ft.	Thickness in.	Total Ft.	Total in.
Shale, sandy, grading to a carbonaceous shale at the base	10		212	
Coal, Wellersburg		3	212	3
Clay	10		222	3
Limestone, nodular, ferruginous	2	6	224	9
Clay-shale, green	2		226	9
Shale, red	3	6	230	3
Clay	7		237	3
Shale, sandy	6		233	3
" red, fissile	10		243	3
Sandstone and sandy shale	25		268	3
Coal, Duquesne		8	268	11
Shale, carbonaceous		4	269	3
Clay, drab, many limestone nodules	12		281	3
Shale, red	12		293	3
" yellow	10		303	3
Limestone, Ames	2	5	305	8
Clay, red, structureless	16		321	8
Sandstone, shaly	12		333	8
Clay	9		342	8
Shale, sandy	8		350	8
Clay	8		358	8
Shale, fissile, flat limestone nodules near base	55		413	8
Limestone, impure, Woods Run		3	413	11
Clay	4		417	11
Shale, red	6		423	11
Clay	5		428	11
Sandstone	3		431	11
Shale, sandy	12		443	11
" gray, fissile	21		463	11
Limestone, sandy, fossiliferous, Pine Creek	1	3	465	2
Clay	4		469	2
Sandstone, medium-grained, cross-bedded, Buffalo	10	6	479	8

Section at Murrysville.

	Thickness Ft.	Thickness in.	Total Ft.	Total in.
Sandstone, Connellsville	20		20	
Concealed	5		25	
Shale	12		37	
Limestone, Clarksburg	2		39	
Coal smut		2	39	2
Fire clay		3	39	5
Shale, sandy	9		48	5
Sandstone, shaly	17		65	5
" massive, Morgantown	58		123	5
Shale, red and brown	30		153	5
" sandy	25		178	5
" red	10		188	5
" sandy	5		193	5
Sandstone, thin-bedded, micaceous	10		203	5
Shale	8		211	5
Shale, carbonaceous		4	211	9
Coal, Duquesne		4	212	1
Clay	5		213	1
Concealed	9		226	1
Shale, red	10		236	1
Limestone, Ames	1		237	1
Clay	20		257	1
Sandstone	15		272	1
Clay, red	6		278	1
Fire clay		4	278	5
Sandstone, coarse-grained	24		302	5
Shale, variegated, occasionally sandy	70		372	5
" drab, fissile	12		384	5
" carbonaceous	2		386	5
" drab	12		398	5
Limestone, fossiliferous, Pine Creek	1		399	5
Shale	3		402	5
Coal		2	402	7
Fire clay	3		405	7
Clay, red	5		410	7
Sandstone, Buffalo	10		420	7

Section at Murrysville.—Continued.

	Thickness Ft.	in.	Total Ft.	in.
Shale, brown	35		455	7
" gray, fossiliferous	11		466	7
Coal, Brush Creek		6	467	1
Clay	2		469	1
Shale, brown	3		472	1
Clay	3		475	1
Shale, brown	20		495	1
" gray, fissile	25		520	1
Coal, Mahoning		5	520	6
Clay	1		521	6

Diamond drill bore-hole half a mile southeast of New Texas.

Surface wash	29		29	
Shale, red	14		43	
" light-colored and red	7		50	
" sandy	5		55	
Sandstone	46		101	
Shale, sandy	12		113	
Slate, dark	1		114	
Coal, Duquesne		6	114	6
Fire clay, impure	9	6	124	
Shale, red and green	3	4	127	4
" light-colored, sandy	6		133	4
" red	12	8	146	
" hard, sandy (Ames limestone)	3		149	
" soft	9		158	
" red	14		172	
" green	13		185	
" red and green	15		200	
" light-colored	6		206	
Sandstone	2		208	
Shale, sandy	10		218	
" bastard	14		232	
" light-colored	11		243	
" sandy	16		259	
Sandstone	20		279	
Shale, hard	11		290	
" red	3		293	
" light-colored, sandy	26	7	319	7
Limestone, impure, Pine Creek	1	2	320	9
Shale, dark	3		323	9
Fire clay, impure	5	3	329	
Shale, dark, sandy	11	3	340	3
" light-colored, sandy	18		358	3
" dark, sandy	30		388	3
Slate, dark (Brush Creek coal horizon)	3	9	392	
Shale, bastard	7		399	
" red and green	6		405	
" sandy	6	6	411	6
" red and dark	7	6	419	
" light-colored, sandy	13	6	459	
" light-colored	10		443	
" red and green	2	6	445	6
" light-colored, sandy	13	6	459	
Sandstone	28		487	
Shale, dark	2		489	
Sandstone	4		493	
Slate, dark	1		494	
Coal, Upper Freeport				

Section at Newlonsburg, Franklin township.

Sandstone, shaly, Morgantown	30		30	
Shale, red	10		40	
Limestone, Wellersburg	1		41	
Clay and soft shale, red	35		76	
Shale, sandy	20		96	
" red	15		111	
Sandstone	5		116	
Shale, red	12		128	
" sandy, and some interbedded sandstone	25		153	

Section at Newlonsburg, Franklin township.—Continued

	Thickness Ft.	Thickness in.	Total Ft.	Total in.
Coal, Duquesne		4	153	4
Clay	6		159	4
Shale, light-colored	9		168	4
Shale, red	10		178	4
Limestone, Ames		8	179	
Clay	8		187	
Coal, Harlem		3	187	3
Clay	1		188	3
Shale, red	16		204	3
Sandstone, thin-bedded	12		216	3
Shale, light-brown and red	18		234	3
Coal, Upper Bakerstown		6	234	9
Clay	1	3	236	
Shale	3		239	
Sandstone, thin-bedded	55		294	
Clay	12		306	
Shale, red	20		326	
Fire clay, white	4		340	
Sandstone	6		346	
Shale	3		349	
Limestone, fossiliferous, Pine Creek		6	349	6
Fire clay, white	3		352	6
Clay-shale	8		360	6
Sandstone	5		365	6
Shale, gray and brown, fissile	40		405	6

Partial record of diamond drill bore-hole at Export.

	Thickness Ft.	Thickness in.	Total Ft.	Total in.
Interval from top of well to base of Pittsburgh coal			29	6
Wash	17	10	47	4
Shale, gray	13	8	61	
" red and gray	4		65	
Limestone	4	6	69	6
Shale, red	4	8	74	2
" gray	6	10	81	
Sandstone	3	4	84	4
Shale, gray	8	6	92	10
" red	11	8	104	6
" gray	8		112	6
" red	8	6	121	
" dark		9	121	9
" gray	18	9	140	6
Limestone	1		141	6
Shale, dark	1		142	6
Limestone and limy shale	16		158	6
Shale, red	3		161	6
" gray	25		186	6
Sandstone	22		208	6
Fire clay	4		212	6
Shale, gray	7		219	6
" red	8		227	6
" gray	6		233	6
" red	8		241	6
" sandy	23		264	6
Sandstone	10		274	6
Shale, gray	9		283	6
" red (includes Ames limestone)	46		329	6
" gray	17		346	6
" sandy	13		359	6
" gray	2		361	6
" red	2	6	364	
" gray	7		371	
" red	20	6	391	6
" gray	61		452	6
" sandy	40		492	6
" gray	3		495	6
Limestone, Pine Creek	2		497	6
Slate	28	9	526	3
Coal		4	526	7
" and sandstone	2	3	528	10

Partial record of diamond drill bore-hole at Export.—Continued.

	Thickness Ft.	in.	Total Ft.	in.
Sandstone	11		539	10
Slate, black	8	10	548	6
Coal, Brush Creek		11	549	5
Fire clay	7		556	5
Shale, gray	9		565	5
Slate, black		3	565	8
Fire clay	6		571	8
Shale, light-colored	10	4	582	
Slate, black (Mahoning coal horizon)	6		588	
Fire clay and red shale	5	9	593	9
Shale, light-colored, sandy	22		615	9
Sandstone, shaly	9	9	625	6
Sandstone	34	11	660	5
Shale, dark, sandy (Upper Freeport coal horizon?)				

Section two to five miles north of Export.

Pittsburgh coal			0	
Fire clay	1		1	
Shale, sandy	4		4	
Sandstone	8		12	
Shale, sandy	11		23	
Limestone	2		25	
Clay	5		30	
Shale, sandy	16		46	
Limestone	1		47	
Coal, shaly		10	47	10
Clay-shale	4		51	10
Sandstone	8		59	10
Limestone	1	6	61	4
Clay		8	62	
Shale, sandy	30		92	
Sandstone, coarse-grained	10		102	
Clay, red, and soft red shale	28		130	
Limestone	1		131	
Clay	3		134	
Sandstone, Morgantown	40		174	
Shale, red	25		199	
" sandy	65		264	
" carbonaceous	5		269	
Clay	3		272	
Shale, red	3		275	
Clay	3		278	
Shale, sandy, light greenish-yellow	20		298	
Shale, red	9		308	
Limestone, Ames	1		309	
Red beds (clay and soft shale)	40		349	
Sandstone	5		354	
Shale, sandy	20		374	
" sandy and interbedded thin sandstone	60		434	
" ferruginous and carbonaceous, sparingly fossiliferous, Woods Run	5		439	
Sandstone, yellow-brown, fine-grained, Saltsburg	35		474	
Shale	3		477	
Limestone, fossiliferous, Pine Creek		6	477	6
Coal, shaly		4	477	10
Fire clay		4	478	2
Clay-shale	12		490	2
Shale, sandy	20		510	2
Sandstone, light olive-green, medium-grained, Buffalo	22		533	2
Shale, gray	8		541	2
" carbonaceous	3		544	2
Coal, Brush Creek	1	6	545	8
Fire clay	1		546	8
Sandstone, light greenish-yellow, medium-grained, Upper Mahoning	5		551	8
Shale, sandy	15		566	8
Concealed	9		575	8
Coal, Mahoning	2	6	578	2

Record of diamond drill bore-hole 600 yards east of B. M. 1077, Bell township.

	Thickness Ft.	in.	Total Ft.	in.
Interval from top of hole to base of Pittsburgh coal			300	
Surface wash	12	3	312	3
Shale, red	23	9	336	
Shale, light-colored	28		364	
" red	5		369	
" light-colored	4	8	373	8
" dark	7	2	380	10
Bone and coal, Upper Bakerstown		3	381	1
Fire clay and soapstone	5		386	1
Shale, light-colored	15	3	401	4
" light-colored sandy	15	1	416	5
Sandstone	24		440	5
Shale, dark	13	10	454	3
" variegated	11	2	465	5
Sandstone	24	1	489	6
Shale, light-colored	1	1	490	7
" dark	18	11	509	6
Coal, Lower Bakerstown (?)	2	7	512	1
Shale, dark	1	6	513	7
Limestone		8	514	3
Shale, sandy, dark	47	5	561	8
" dark	16	5	576	1
Sandstone	15		593	1
Shale, light-colored, sandy	5	9	598	10
Limestone and shale		11	599	9
Shale, light-colored	3		602	9
" dark, sandy	8	2	610	11
Coal, Mahoning	3		613	11
Soapstone (flint clay?)	5		618	11
Limestone		2	619	1
Limestone and shale	1	5	620	6
Shale, light-colored	2	2	622	8
Limestone		5	623	1
Shale, light-colored	3	3	626	4
" dark	1		627	4
" dark sandy	4	3	631	7
Fire clay	1	8	633	3
Shale, variegated	13	6	646	9
Sandstone	3		649	9
Shale, light-colored, sandy	3	4	653	1
Shale, dark, sandy	14	5	667	6
Coal, Upper Freeport				

Section at Jeannette.

Sandstone	8		8	
Clay-shale	12		20	
Sandstone and shale, inter-bedded	40		60	
Concealed	14		74	
Shale, carbonaceous		2	74	2
Clay, olive drab	6		80	2
Shale, brown to greenish-yellow	4		84	2
" red	3		87	2
" greenish-yellow	8		95	2
Limestone, Ames	1		96	2
Clay	4		100	2
Concealed	50		150	2
Shale, light brown	10		160	2
" gray		6	160	8
Limestone, ferruginous, shaly, fossiliferous, Woods Run		5	161	1
Clay	1		162	1
Concealed	12		174	1
Shale, drab	5		179	1
Concealed	5		184	1
Clay	2		186	1
Limestone, fresh-water, nodular		4	186	5
Clay, partly concealed	14		200	5
Shale, sandy	11		211	5
" brown and gray	42		253	5
Coal, shaly		4	253	9
Clay, partly concealed	10		263	9
Shale, light greenish-yellow	12		275	9

Section at Jeannette—Continued.

	Thickness Ft.	Thickness in.	Total Ft.	Total in.
Shale, sandy	14		289	9
Sandstone	6		295	9
Clay-shale	2		297	9
Coal, bright, blocky (Brush Creek?)		10	298	7
Clay	13		311	7
Shale	4		315	7
" sandy	22		337	7
" carbonaceous	1		338	7
" limy, contains fresh-water fossils	1		339	7
Clay-shale with limestone nodules	5		344	7
Clay, contorted	8		352	7
" gray	7		359	7
Sandstone	7		366	7
Shale	12		378	7
Coal, shaly, Mahoning	5		379	
Clay, gray	3		382	
Shale, light yellow	5		387	
Sandstone, thin-bedded and shaly to massive at base	60		447	
Clay-shale	9		456	
Coal, Upper Freeport				

Section along Pennsylvania Railroad going east from the eastern boundary of the quadrangle.

	Thickness Ft.	Thickness in.	Total Ft.	Total in.
Pittsburgh coal			0	
Fire clay	1		1	
Limestone, impure, and nodular clay, interbedded	9		10	
Sandstone and shale, interbedded	14		24	
Limestone	4		28	
Clay-shale		6	28	6
Coal, shaly		8	29	2
Shale		4	29	6
Clay	4		33	6
Sandstone and shale, inter-bedded	12		45	6
Limestone	4		49	6
Clay-shale	1		50	6
Limestone	2		52	6
Clay	1	8	54	2
Limestone		9	54	11
Clay with limestone nodules	3		57	11
Shale, gray	13		70	11
Sandstone	10		80	11
Shale	9		89	11
Limestone		6	90	5
Clay	6		96	5
Shale, light yellow	14		110	5
Sandstone, hard, flaggy	7		117	5
Shale	14		131	5
Limestone, Clarksburg, and clay in about equal amounts	21		152	5
Shale, greenish-yellow, weathers red	14		166	5
Clay, limestone nodules	10		176	5
Shale and sandy shale	27		203	5
" black, carbonaceous	1		204	5
Coal, bony, Wellersburg		5	204	10
Clay	12		216	10
Limestone, nodular, shaly	1	6	218	4
Shale, brown to gray and sandy	49		267	4
Clay	12		279	4
Shale, fissile	23	6	302	10
Limestone and shale, Ames	3		305	10
Shale, black	3		308	10
Coal, Harlem	1	2	310	
Clay, red	14		324	
Shale, red	7	6	331	6
Clay, red, contains many limestone nodules	14	8	346	2
Shale, soft	14	6	360	8
Clay, red	9		369	8
Sandstone, with some inter-bedded shale	15		384	8
Shale, yellow	5		389	8
Shale, greenish-gray	21		410	8
" fissile, gray, contains limestone nodules	13		423	8

Section along Pennsylvania Railroad going east from the eastern boundary of the quadrangle.—Continued.

	Thickness Ft.	in.	Total Ft.	in.
Limestone, shale, ferruginous, nodular, fossiliferous, Woods Run		4	424	
Shale, sandy	6		430	
Sandstone, massive-bedded, conglomeratic at the base	65		495	
Shale, gray	22	6	517	6
Limestone, fossiliferous, Brush Creek	1	6	519	
Shale, sandy, gray	14		533	
Coal, bony } Brush Creek		6	533	6
Coal, }		3	533	9
Clay	6		539	9
Sandstone, badly cross-bedded	6		545	9
Clay	5		550	9
Sandstone, limy, shaly	2		552	9
Shale, sandy	10		562	9
" gray, fissile	15		577	9
Coal, Mahoning	4		581	9
Clay	12		593	9
Sandstone	7		600	9
Concealed	15		615	9
Sandstone	20		635	9
Shale	4		639	9
Coal, Upper Freeport				

The many shorter sections measured in the vicinity of Greensburg are uniformly thicker than the corresponding part of the section just given. Hence it is likely that insufficient allowance was made for structure in compiling the section.

Upper Pittsburgh limestone. Underlying the Pittsburgh coal and usually within a foot of its base, there is ordinarily found a dark, impure, nodular limestone, commonly less than one foot thick, and known as the Upper Pittsburgh limestone.

Beneath this bed, and extending for nearly 100 feet below the Pittsburgh coal, are sandstone, limestone, and shale beds, which vary so greatly from point to point that it would be impractical to attempt to give enough sections to properly illustrate all phases of this part of the Conemaugh group. Fig. 4 contains a few typical sections.

Lower Pittsburgh limestone. The name Lower Pittsburgh has been given by various geologists to a limestone bed occurring between the Upper Pittsburgh limestone and the Clarksburg limestone, but since as many as six limestone beds have been found in that interval, the use of the name is ambiguous. The character of these beds changes considerably from point to point, but at one place it will be noted that the limestones increase in purity with an increase in their distance from the Pittsburgh coal above. The limestones close to the coal may contain a small number of ferruginous concretions. Minute, snail-like fossils (spirorbis) are common in the Pittsburgh limestones in some places. At any one point they are usually confined to one or two of the beds.

Quite commonly in the northwestern, central, and southern parts of the quadrangle a very massive limestone bed is found 20 to 40 feet below the base of the Pittsburgh coal. This limestone weathers to a characteristic buff color with rusty iron streaks. In the southern part of the quadrangle it is five feet thick in places.

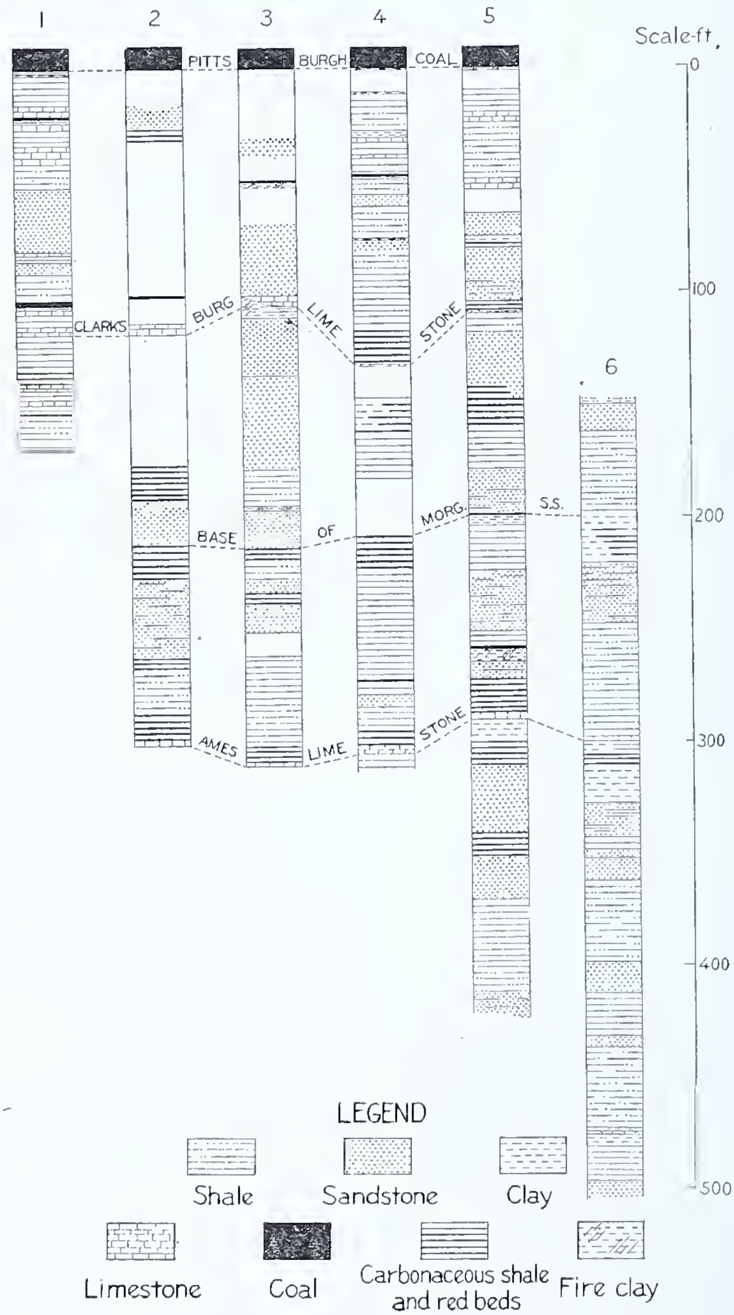
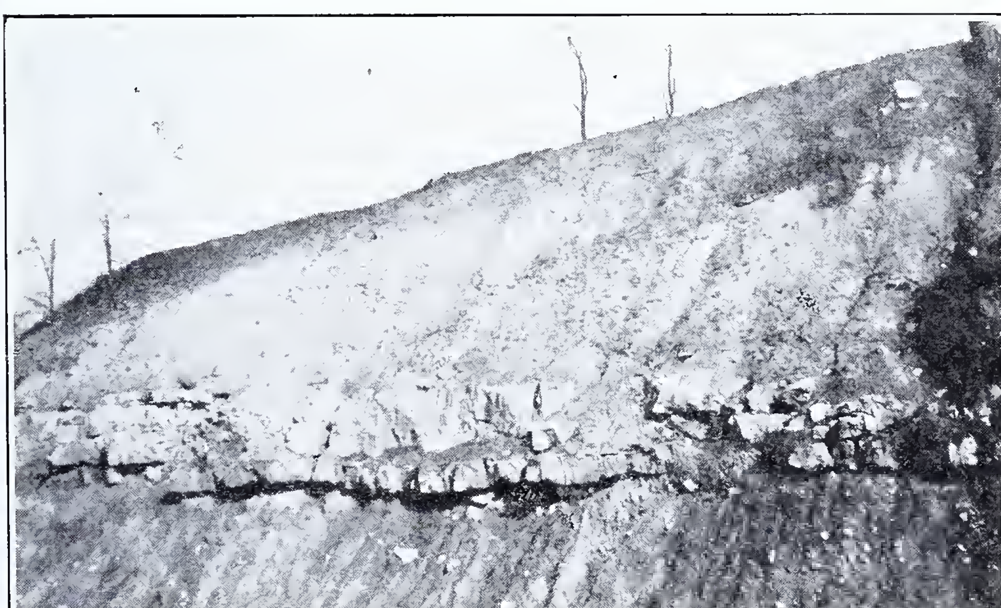


Fig. 4 Sections of the upper part of the Conemaugh group.

1. Section at west end of Radebaugh tunnel, main line of Pennsylvania Railroad.
2. Section west of B. M. 1329, two miles north of Hannastown, Salem township.
3. Section in Bell township from B. M. 1077, near Beaver Run, to B. M. 1316.
4. Section from Sardis, northwest part of Franklin township, towards the east.
5. Section one mile west of Pleasant Valley, Penn township.
6. Section in quarry of Wynn & Starr Company in Patton township, one-half mile northeast of Blackburn.

A. Base of Sewickley sandstone. in first railroad cut east of the Pennsylvania Railroad station at Irwin. Redstone limestone just above track.

B. Connellsville sandstone and red beds in railroad cut $\frac{3}{4}$ mile west of Irwin station.



C. Pittsburgh limestone, 40 feet below coal, in railroad cut 600 yards west of Irwin station.

At different points in the quadrangle thin coal beds, usually shaly or bony, have been found at three different horizons in this interval (Upper Pittsburgh limestone to Clarksburg limestone). They have been called Upper and Lower Little Pittsburgh, and Little Clarksburg, in accordance with the previous usage of those terms. They are not of workable thickness in this quadrangle nor are they of stratigraphic importance. The columnar section shows the average intervals at which they are found beneath the base of the Pittsburgh coal.

In the northeastern part of the quadrangle the Pittsburgh limestones are quite replaced by sandstone.

Lower Pittsburgh sandstone. This a flaggy sandstone occasionally occurring close beneath the Pittsburgh coal. It is at least 20 feet thick. These Lower Pittsburgh limestones do not occur and the Lower Pittsburgh sandstone merges with the Connellsville in such a manner that it is impossible to separate them. The combined thickness amounts to as much as 60 feet in places.

Connellsville sandstone. Between the Pittsburgh limestones and the Clarksburg limestone there is usually a thin-bedded micaceous, medium-grained sandstone. This sandstone corresponds to the sandstone found at this horizon near the town of Connellsville, and is known by that name. In some places it is massive enough to be quarried. More often it is represented by a sandy shale or interbedded sandstone and shale. It is nearly always cross-bedded. The maximum thickness of the Connellsville is probably not over 40 feet. Where massive, the lower beds are up to 30 inches thick. The thickness of the beds decreases towards the top of the sandstone. The following section was exposed in a quarry just south of Huff, Hempfield Township:

Section of Connellsville sandstone near Huff.

	Feet
Shale, sandy, olive drab to reddish	13
Sandstone, fine-grained, micaceous, soft, dark olive drab to rusty brown	17

In a small quarry west of Larimer, 15 feet of good, massive sandstone was noted. Joint planes in the sandstone contained a considerable amount of calcite, probably derived by solution from the Pittsburgh limestones above.

Clarksburg limestone. At an interval varying from 100 to 160 feet below the base of the Pittsburgh coal (interval increases from west to east) there is nearly always found a limestone bed or group of beds which has been termed Clarksburg limestone in conformance with previous nomenclature. The Clarksburg limestone beds are

as a rule, compact, light-gray, or blue-gray in color, more nearly pure than the average fresh-water limestone, and often contain fresh water fossils. They break with a smooth, conchoidal fracture, and the fresh surface usually shows many small, sparkling, calcite crystals.

The Clarksburg limestone is much thicker in the southeastern part of the quadrangle than elsewhere. The following sections illustrate its thickness and character at different points in the quadrangle.

Section 2 miles south of Plum Creek Church.

	Feet
Shale and sandy shale	40
Limestone, pure, mottled, dove colored, and showing scattered calcite crystals on fresh fracture, Clarksburg	2
Sandstone and sandy shale	45

Section 2½ miles north of Delmont.

Sandstone, shaly, thin-bedded	22
Shale, sandy	2
Limestone, 2 beds, upper containing many spirorbis, Clarksburg	2
Shale, greenish-gray, poorly stratified	10

Section in cut of the Pennsylvania Railroad at Radebaugh.

	Ft.	in.
Shale, gray, sandy	14	
Coal, bony, Little Clarksburg		2 to 12
Shale, sandy	1	6
Limestone, light-gray, Clarksburg		6
Shale, dark-gray	1	
Limestone, blue-gray, calcite crystals, Clarksburg	2	
Shale, gray, fissile	5	
Limestone, gray, partly weathered to a rusty color, Clarksburg	4	
Shale, variegated, limestone nodules	15	
Shale finely laminated	4	
Limestone, gray, rusty, Clarksburg	3	
Shale, gray, fissile, limestone, nodules	4	
Limestone, gray, nodular, Clarksburg	2	
Shale, gray, limy	4	
Limestone, light-gray, Clarksburg		6
Shale and sandy shale		

Section 1 mile northwest of Irwin.

	Feet
Shale, red	10
Limestone, Clarksburg	2
Sandstone, massive	10+

Morgantown sandstone. Close beneath the Clarksburg limestone there is usually a massive-bedded, medium-grained, light-gray to buff colored, cross-bedded sandstone which has been called Morgantown, since it corresponds in stratigraphic position to the sandstone of that name at the type locality. It is micaceous, arkosic (as are all of the sandstones hereabouts), and like the other massive-bedded sandstones, the beds decrease in thickness towards the top of the member. Although not always present as a compact sandstone, the Morgantown horizon is persistently sandy throughout the entire quadrangle. A thin coal, the Wellersburg,* sometimes marks the

*The name Wellersburg was given the coal immediately beneath the Morgantown sandstone because the name Elk Lick, previously given this bed, has been used indiscriminately for every coal bed between the Upper Freeport coal and the Clarksburg limestone, and because Dr. Charles K. Swartz has given the coal that name at its type locality near Wellersburg, Somerset County. The Wellersburg coal here described is the Elk Lick coal of the West Virginia Geological Survey.

base of the sandstone. More often the coal is missing and the Wellersburg clay occurs directly beneath the sandstone.

The interval between the Wellersburg clay and the gray and sandy Birmingham shale is occupied by red shales and clays of variable thickness and extent. The name Schenley is sometimes attached to these red beds because of their excellent exposure in the Schenley district, Pittsburgh.

Wellersburg coal. The Wellersburg coal, mentioned above, is well exposed along the main line of the Pennsylvania Railroad 600 yards west of Larimer. There it is only three inches thick. A diamond drill hole at Irwin went through the same thin coal at a depth of 237 feet below the base of the Pittsburgh coal. One mile east of Arona the Wellersburg crops out on opposite sides of a hill and is there one foot thick. It is underlain by clay and limestone and overlain by massive-bedded sandstone (Morgantown). Two and one half miles south-east of Mamont and just east of B. M. 1066 there is an old, caved-in opening in what may be the Wellersburg where the coal is said to be 18 inches thick. It is overlain by 100 feet of Morgantown sandstone, a maximum thickness for the latter.

Birmingham shale. Beneath the Wellersburg clay, or limestone if present, and extending down to the Duquesne coal, is the Birmingham shale. In this quadrangle this horizon is more often sandy than not and frequently contains a considerable number of compact sandstone beds. The latter phase is well shown along the main line of the Pennsylvania Railroad east of Ardara Station. Incidentally it is so much cross-bedded there that at first sight there seems to be a reversal of dip in the rocks. The sandstone beds are massive and lenticular and seemingly dip towards the west. Closer inspection reveals an opposite dip, however.

The Birmingham shale averages 60 to 65 feet thick and usually contains both red beds and sandstone lenses. The character of the beds between the Clarksburg limestone and the Ames limestone is illustrated in the following sections.

Section 1 mile southeast of Newlonsburg.

		Feet
Sandstone (inferred from fragments)		15
Shale, red		4
Sandstone, thin-bedded	Morgantown	20
Shale, red and buff	Morgantown	15
" and sandy shale	Morgantown	32
Shale, red		7
Limestone, Wellersburg		2
Shale, red		10
" sandy		20
" red		15
Sandstone		5
Shale, red		5
" sandy and sandy shale		48
Limestone, fossiliferous, Ames		1

Section 3 miles east of Mamont.

		Feet
Clay, Clarksburg horizon		5
Sandstone, medium-grained, hard, iron-stained	Morgantown	25
" (inferred from float)	Morgantown	35
Shale, sandy, and inter-bedded sandstone	Morgantown	15
" red, and sandy shale		8
Clay, Wellersburg		4
Shale, sandy		15
" red		3
Sandstone, flaggy, micaceous		12
" (inferred from float)		12
Shale		30
Limestone, fossiliferous, Ames		2

Section 2 miles west of Murrysville.

		Ft.	in.
Limestone, Clarksburg		2	6
Shale, carbonaceous			6
Fire-clay			3
Shale, sandy	Morgantown	8	
Sandstone, shaly	Morgantown	17	
" greenish-gray, micaceous coarse-grained	Morgantown	58	
Concealed		47	
Shale, red		10	
Concealed		5	
Sandstone, thin-bedded, micaceous		10	
Concealed		8	
Shale, carbonaceous			4
Coal, Duquesne			4
Concealed		22	
Limestone, fossiliferous, Ames		2	

Section 1 mile south of Huff.

	Ft.	in.
Limestone, gray, mottled, Clarksburg	6	
Clay	11	
Sandstone, brown, thin-bedded, Morgantown	7	
Shale, sandy, yellow, Morgantown	6	
" yellow	7	
Clay-shale, red	5	
Concealed	22	
Sandstone, shaly, Morgantown	13	
Concealed	27	
Shale, gray	9	
Sandstone, thin-bedded	1	6
Shale, gray	17	
" carbonaceous, Duquesne coal horizon		6
Clay	8	
Shale, yellow	8	
" red	6	
Limestone, fossiliferous, Ames	1	

Duquesne coal. Marking the base of the Birmingham shale and found frequently at a distance of 16 to 40 feet above the Ames limestone, is a thin coal bed which has at various times been called Barton, Elk Lick and Duquesne. In view of the confusion relative to the first two of these names, the author has chosen to use the name *Duquesne,* given this coal bed by Percy E. Raymond[6], and which has been used to designate this bed alone.

[6] Raymond, Percy E., Preliminary list of the fauna of the Allegheny and Conemaugh series, in western Pennsylvania: Carnegie Mus., Annals, Vol. VII, pp. 144-158, 1910.

Although a thin seam, the coal is often of good quality and breaks out in blocky chunks. Two hundred yards east of Larimer on the Pennsylvania Railroad the coal is 8 inches thick and lies 35 feet above the Ames limestone. On the east side of the Irwin syncline the Duquesne coal horizon is exposed along the Pennsylvania Railroad tracks a quarter of a mile east of Penn station. There it is represented by only 2 inches of black carbonaceous shale, and lies only 22 feet above the Ames. On the west side of the Greensburg syncline it is lacking at many places and was not noted at any point on the eastern side of the syncline. Generally speaking the coal is thicker and more persistent towards the west.

Section 1½ mile east of Boquet.

	Feet
Shale and sandy shale	30
Shale, red	5
Sandstone, thin-bedded	15
Shale, red	10
Shale	13
Coal, Duquesne	2±
Clay-shale and shale	18
Limestone, Ames	2

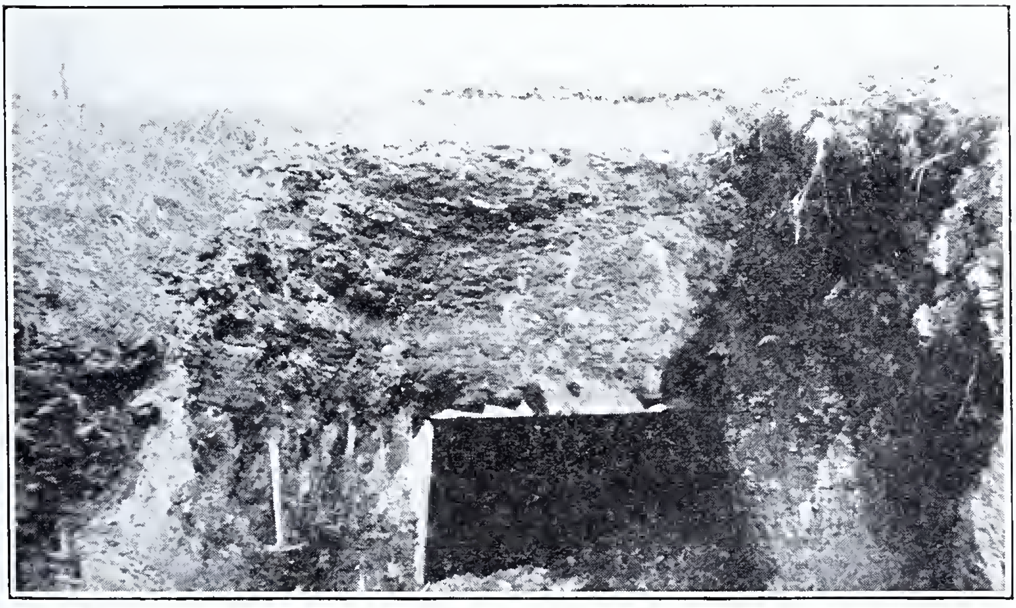
South of Delmont a good section from the Pittsburgh coal down to the Saltsburg sandstone, was obtained along the road.

Section 1 mile south of Delmont.

	Feet
Coal, Pittsburgh	6+
Concealed	18
Sandstone, thin-bedded and some fire-clay	18
Concealed	48
Sandstone, thin-bedded, micaceous, shaly, drab	22
Concealed	26
Shale, black bituminous, Little Clarksburg coal horizon	1
Fire clay, gray and red shale	13
Sandstone, thin-bedded, fine-grained, olive-brown	8
Shale, drab and red	15
Sandstone, thin-bedded, soft, gray micaceous	19
Sandstone, massive, brown, medium grained	35
Shale, drab	5
Limestone, Wellersburg, brown, impure, fresh-water nodular	2
Shale, red	10
Shale, structureless to bedded drab and red sandy	16
Sandstone, thin-bedded, and sandy shale	15
Shale, drab	2
Shale, black, bituminous, Duquesne coal horizon	3
Shale, light green and red	18
Limestone, Ames	2½
Clay, red and shale	15
Sandstone, thin-bedded, brown, nodular, iron-stained	10
Shale, sandy	10
Sandstone, thin-bedded, brown, and sandy shale	33
Wash	5+

One mile east-southeast of Delmont and just east of B. M. 1116 an old opening which permitted a good measurement showed the Duquesne coal 30 inches thick and underlain by 34 inches of carbonaceous shale and bony coal. The Ames limestone was found in place just 16 feet below the coal.

A. Duquesne coal along railroad track, 200 yards east of Larimer.



B. Entry in Duquesne coal one mile east-southeast of Delmont.

The Duquesne coal is entirely lacking in the northeastern and north central parts of the quadrangle, but in the northwestern part the coal, in every case less than 10 inches thick, was noted at several points on the surface and in several diamond drill holes. Towards the southwest the coal is quite persistent.

The Duquesne coal is usually underlain by clay and in places by a limestone. Shale or sandy shale separates the Duquesne horizon from a quite persistent thin sandstone which is nearly always found from ten to twenty feet above the Ames limestone. The remaining ten to twenty feet is shale, green above and red below. Although there is no apparent change in the texture or composition of the shale, the line between the red and green shale is often sharply drawn, indicating a sudden change in the quantity of iron that was being deposited with the mud which later was compacted into shale.

Ames limestone. The appearance of the Ames limestone in this area is quite similar to the description given in former publications. It is typically a greenish-gray, rough-appearing marine limestone, which is always abundantly fossiliferous. Stratigraphically, it is the highest marine limestone in the quadrangle. It is fairly hard and compact, and when broken the fresh surface nearly always exhibits many sparkling calcite plates of broken crinoid stems. The weathered surface is rough with projecting crinoid stems and other fossils which resist weathering. Often the limestone consists almost entirely of crinoid stems and a jumbled mass of the beaks of *Ambocoelia planiconvexa,* a marine bivalve shellfish. *Lophophyllum profundum, Chonetes granulifer,* and other small marine shell-secreting animals are abundant. Many other species are more or less abundant depending on the locality. Where well developed the Ames usually occurs in two or three comparatively thin beds in close proximity seldom exceeding a total thickness of 30 inches. In most places it is a single bed 10 or 12 inches thick.

Occurring near the middle of the Conemaugh and being easily recognized, the Ames limestone is a very important horizon marker in this quadrangle. The interval between the Ames and the Pittsburgh coal is not constant but varies slightly from point to point. By obtaining accurate measurements of this interval wherever possible, the true interval at any one point can be figured very closely, however. In general there is a thickening of the strata between the Ames and the Pittsburgh coal towards the southeast; so that whereas the interval is 280 feet near Murrysville, at Greensburg it is 340 feet.

The following table gives the thickness of the Ames and the intervals to the Pittsburgh coal at different points.

Thickness of Ames limestone and distance below Pittsburgh coal.

Location	Thickness Ft.	in.	Interval Feet
South of Fosterville, near the Pennsylvania R. R., and just over the southern boundary of the quadrangle		3	345
¼ mile southwest of Middletown, Hempfield township	2	8	325
On P. R. R. ¾ mile east of Penn Station	1		320
On P. R. R. ¼ mile east of Ardara Station	2		310
Quarry at Blackburn, Turtle Creek branch of P. R. R.. ..	2	4	295
1 mile southeast of Newlonsburg, Franklin township	1	6	280
Just south of Mamont cross-roads, Washington township	2		290
2 miles south of Sardis, Franklin township	1	6	300
¾ mile east of Delmont, Salem township	1	4	300
1 mile west of northeast corner of quadrangle	1	4	300
3½ miles east of Boquet, Penn township	1	2	320

Harlem coal. Either immediately beneath or within ten feet of the Ames limestone is often found a thin coal bed of fairly good quality known as the Harlem coal. In this quadrangle the seam is nowhere over 30 inches thick and is usually much less; hence its economic value is small. Where it occurs, however, it is a good marker for the Ames and is also useful in identifying the Ames in drill hole or shaft sections.

As a sweeping generalization it may be said that the coal is missing or very thin in the western half of the quadrangle and reaches its maximum development in the Greensburg basin. Thus, along the Pennsylvania Railroad near Ardara the Harlem coal is found immediately below the Ames, but is there only half an inch thick. At Rillton, Export, and in the northwest corner of the quadrangle, diamond drill holes failed to show any Harlem coal whatever. At Irwin and Biddle, 12 inches and 9 inches of coal, respectively, were noted. As no coal was seen beneath the Ames at many good outcrops on both flanks of the Murrysville anticline it is believed that the Harlem coal found in the aforementioned drill holes represents only a very local development of the coal, and is the maximum development in that area. In the northeastern part of the quadrangle also, the coal is missing, the most northerly outcrop noted being about three-quarters of a mile due east of Delmont. Here, strange to say, the coal is 14 inches thick and a small opening, now caved-in, is evidence that someone once thought the coal thick enough to be worked. That this is only a local development of the Harlem is proven by the fact that little or no trace of it was observed beneath the Ames at outcrops a mile distant.

Farther south the coal becomes more persistent and was seen in many outcrops. The thickness varied from 10 to 16 inches. South of the main line of the Pennsylvania Railroad and on the eastern slope of the Greensburg syncline it occurs quite generally and varies in thickness from a few inches to a maximum of 26 inches at an old opening a quarter of a mile north of the southern boundary of the quadrangle and three-fourths of a mile west of the eastern boundary.

Pittsburgh red beds. Nearly always the Ames limestone (or the Harlem coal when present) is underlain by red clay and shale which make a very noticeable band of color wherever exposed. At a few points where the Ames was either lacking or concealed, the Ames horizon was mapped by means of these red beds. Known as the Pittsburgh red beds, these clays and shales vary in thickness from 5 to 60 feet. The average thickness is about 35 feet. The upper part of the red beds is a structureless red clay, usually about 15 feet thick. The lower part is red shale.

Saltsburg sandstone. The Saltsburg horizon is considered to extend from the red beds beneath the Ames limestone to the top of the Pine Creek limestone. This includes as much as 100 feet of sandstone in some localities. At the type locality just three miles east of the northeast corner of the quadrangle there is a thickness of 120 feet of sandstone, but this great thickness is due to the fact that the Pine Creek limestone and associated clay have been entirely cut out and the underlying Buffalo sandstone is continuous with the Saltsburg. In general the sandstone greatly resembles the other prominent sandstone members of the Conemaugh. It is variable in character and thickness and changes greatly in short distances. Where massive it is medium-grained, arkosic, hard and resistant to weathering. It is usually cross-bedded, the beds ranging from a few inches to several feet in thickness. The color of the sandstone will sometimes serve to distinguish it, although it should not be relied upon as furnishing a definite criterion for that purpose. The color is best described as light-brown with a tendency towards orange. It is brighter than the color of any other sandstone outcropping in the quadrangle. The following sections are illustrative of the character and thickness of the sandstones in different parts of the quadrangle.

Section 1 mile west of the northeast corner of the quadrangle.

	Ft.	in.
Limestone, fossiliferous, Ames	1	4
Red beds	25	
Sandstone, soft, thin-bedded, shaly, Saltsburg	35+	

Section from B. M. 1345 on Five Points-Delmont road to southwest.

	Feet
Limestone, fossiliferous, Ames	1
Concealed, sandy soil	55
Sandstone, brown, coarse-grained, massive to medium-bedded, Saltsburg	70
Shale	15+

Section 1 mile south of the north boundary of the quadrangle and 1 mile west of Beaver Run.

	Ft.	in.
Limestone, Ames	2	
Shale and clay, red	5	
Sandstone, thin-bedded, olive-green, Saltsburg	45	
Fire clay		6
Coal, Bakerstown		3
Fire clay		6
Sandstone, shaly, Saltsburg	50	
Clay-shale, ferruginous, carbonaceous smut	3	

Section 1¼ miles north of Manordale, Franklin township.

	Ft.	in.
Limestone, Ames	1	6
Clay and shale, red	20	
Sandstone, thin-bedded, Saltsburg	40	
Shale, sandy, and inter-bedded sandstone, Saltsburg	25	
" sandy, fissile, olive-green	30+	

Section from B. M. 1022, 1¾ miles north-northwest of Murrysville, to Thompson Run.

		Feet
Limestone, Ames		2
Red beds		25
Sandstone, hard, Saltsburg		8
Shale, red		8
Shale, sandy	Saltsburg	5
Sandstone	Saltsburg	10
" and sandy shale	Saltsburg	25
Shale, drab, fissile		30+

Section at Wynn and Starr quarry, ½ mile north of Blackburn, Penn township.

		Ft.	in.
Limestone, Ames		2	4
Clay-shale, carbonaceous		1	
Shale, carbonaceous, Harlem coal horizon		2	4
Clay, red		17	
Sandstone, brown, ferruginous, shaly, nodular	Saltsburg	15	
Shale, fissile	Saltsburg	6	
Sandstone, thin-bedded	Saltsburg	4	
" cross-bedded, massive	Saltsburg	10	
Shale, sandy and interbedded sandstone	Saltsburg	36	
Sandstone, buff, fine-grained, cross-bedded massive	Saltsburg	14	
Shale, fissile	Saltsburg	18	
Sandstone, brown, fine-grained, thin to massive-bedded	Saltsburg	5	
Shale, fissile to sandy		20+	

Section 1¼ miles southeast of Claridge, Penn township.

		Feet
Limestone, Ames		2
Red beds		20
Sandstone and sandy shale, buff	Saltsburg	20
Concealed, sandy soil with sandstone fragments	Saltsburg	65
Sandstone, thin-bedded, micaceous	Saltsburg	75

Section 1 mile northwest of the southeast corner of the quadrangle.

	Feet
Coal, Harlem	1
Concealed	10
Sandstone, flaggy, Saltsburg	20
Concealed	105
Sandstone, buff, flaggy to massive-bedded, Saltsburg	10

Section 1½ miles southeast of Arona, Hempfield township.

	Feet
Limestone, Ames	1
Red beds	5
Concealed	18
Sandstone and sandy shale, Saltsburg	14
Concealed	6
Shale, purplish	5
Concealed	16
Shale, sandy, and shaly sandstone, Saltsburg	10
Concealed	

Section at Ardara Station, North Huntingdon township.

	Feet
Limestone, Ames	2
Red beds	16
Sandstone, thin-bedded, shaly, Saltsburg	10
Clay	11
Sandstone, greenish-yellow, micaceous, Saltsburg	10
Shale, drab, sandy	20

Section just south of Blackburn, Penn township.

	Feet
Limestone, Ames	2
Red beds	25
Sandstone, light-brown, Saltsburg	28
Clay-shale, orange	5
Sandstone, Saltsburg	20
Concealed	50
Shale, gray to drab, sandy	48

Diamond drill holes show that in the Irwin basin the Saltsburg horizon is less sandy than elsewhere, little sandstone being recorded in any of the holes.

Upper and Lower Bakerstown coals. These coals occur below the Saltsburg horizon and are exceedingly variable in thickness and extent. They occur at average intervals of 60 and 120 feet respectively below the Ames, but these intervals are subject to considerable variation. In fact, during the course of his field work the writer became convinced that the name Bakerstown as applied to the coal at any one horizon could be very misleading. For (in the case of either coal bed) instead of a continuous coal bed extending throughout the quadrangle, there is a succession of coal pockets. At one point there may be three feet of coal; half a mile in any direction the coal disappears. This "pockety" nature of the Bakerstown detracts considerably from its value as it necessitates very thorough prospecting to make sure that the coal is of sufficient extent in any one locality to warrant mining. The high content of ash and sulphur also detracts from its value.

Of the two coals, the Upper is perhaps the more persistent and is found in the extreme northwest, at several points in the northeast, and in much of the central and southeast parts of the quadrangle. At no point, however, is it thick enough to be worked, in most places measuring less than six inches. The greatest thickness noted, 16 inches, was three-fourths of a mile northwest of Pennine in Hempfield township.

The Lower Bakerstown, while very erratic in its occurrence, is a much more valuable coal. It has been mined on a small scale at several points in the south-central part of the quadrangle and in 1922 was being mined at several country banks west of Pennine where the coal attains a very unusual thickness.

Section in the Baughman mine.

	Ft.	in.
Clay	3+	
Coal, with a few thin partings	7	2
Fire clay	1	
Sandstone	2+	

This great thickness is local however. Diamond drill-holes on adjacent properties have proved that the coal thins very rapidly to the north and east. To the south, across the valley of Little Sewickley Creek, the coal thins to 30 inches and in another half-mile pinches down to a scant six inches.

The coal could not be found in the hill to the west although several holes were put down in search of it.

The following sections illustrate how the Lower Bakerstown coal thins to the north:

Section 1¾ miles south of Grapeville.

	Ft.	in.
Shale	3+	
Coal	4	9
Coal, bony	1	

Section 1 mile northwest of Jeannette.

	Ft.	in.
Shale, sandy	20+	
Coal		4
Clay		2
Coal		5
Fire clay		

Section 2 miles northwest of Jeannette.

	Ft.	in.
Sandstone, thin-bedded, shaly, micaceous	10+	
Shale, black	3	
Coal		10
Fire clay		5+

The Lower Bakerstown coal is 13 inches thick just east of Beaver Run and half a mile south of the northern boundary of the quadrangle. At other points in the northeast it is thin or missing. In the western half of the quadrangle the Lower Bakerstown is missing.

Woods Run limestone. So named because of its discovery and good exposure at Woods Run near Pittsburgh, this fossiliferous, marine limestone, typically thin and nodular, is found only in the western part of this quadrangle. Because of the characteristics mentioned the limestone has little value as a key rock in determining the stratigraphy, and no economic value.

The limestone is usually impure, containing much clay, carbonaceous material, and sand. In some places it is highly ferruginous. Locally thin coal or carbonaceous shale is found immediately beneath the limestone. Percy E. Raymond has listed some of the fossils found in the Woods Run in the Pittsburgh district in an article entitled, "A Preliminary list of the fauna of the Allegheny and Conemaugh series in Western Pennsylvania.[7]

The Woods Run limestone is found at intervals varying from 24 to 70 feet above the Pine Creek limestone. The usual interval is 50 feet. This is in what has been defined previously as the Saltsburg horizon.

Pine Creek limestone. In the Greensburg quadrangle the Pine Creek limestone is found most persistently on the Murrysville anticline. There it is a light gray, hard, compact, fossiliferous limestone, and is an important key horizon. When weathered it frequently has a characteristic concave surface not exhibited by any of the other limestones in the Conemaugh group. Productus, crinoids, spirifers, and bryozoans are some of the fossils frequently seen. In that region the Pine Creek varies in thickness from four inches to two feet. Often the shale immediately above the Pine Creek contains well preserved fossils. The average interval from the Pine Creek to the Upper Freeport coal is about 175 feet. The interval to the Ames is about the same.

On the Grapeville anticline the Pine Creek limestone is less persistent and thinner and is much more difficult to trace. It was observed in few places and consequently could not be relied upon as a key rock in determining the structure of that area. It was found at several places on the Fayette anticline, but is thin and usually altered to a ferruginous clay where it outcrops.

Frequently a coal ranging from a fraction of an inch to 16 inches thick occurs just beneath the Pine Creek limestone. The coal is of poor quality and for many years at least cannot be thought of as possessing any value.

The Pine Creek limestone usually is underlain and overlain by soft shale. A thin bed of clay may lie beneath it, as in a typical section 1½ miles west of Murrysville.

Section 1½ miles west of Murrysville.

	Ft.	in.
Shale, sandy and thin-bedded sandstone (Saltsburg)	50+	
Shale, drab, fissile	15	
Sandstone, thin-bedded, ferruginous, nodular, micaceous	5	
Concealed	10	
Limestone, Pine Creek	1	6
Shale	3	
Coal		2
Clay	2	

[7] Raymond, Percy E., op. cit.

Buffalo sandstone. A few feet below the Pine Creek limestone is found the Buffalo sandstone. This sandstone in places is very massive and is prominently exposed along Brush Creek and Turtle Creek near the western boundary of the quadrangle. There it is fine to medium-grained, gray on fresh fracture (weathers to a light yellow-gray), and is massive bedded. It is commonly cross-bedded and in general has very much the appearance of the Morgantown sandstone. It is also well exposed along the Grapeville anticline but is more argillaceous there and hence exposures are not so prominent.

East of Greensburg, in the big cut at Donohoe, the Buffalo sandstone is again very massive and sandy and contains fair-sized pebbles near the base of the stratum. It crops out quite extensively along the Murrysville anticline but losses its massive character in the vicinity of the village of Murrysville. In several localities, notably in the northeast part of the quadrangle, the Pine Creek horizon is completely cut out and the Saltsburg and Buffalo sandstone unite.

It is difficult to estimate the thickness of the Buffalo sandstone since in so many places either the Pine Creek or Brush Creek limestone—marking the top and bottom respectively of the Buffalo sandstone—is missing. Probably it is safe to say that forty feet would be a maximum thickness in this quadrangle. Usually the sandstone is much thinner.

Brush Creek limestone. Associated always with a dark shale and occurring a few feet beneath the Buffalo sandstone is found usually the impure, easily weathered Brush Creek limestone. Because of its easy disintegration, it is difficult to trace in this region. It is abundantly fossiliferous and where found is stained dark by iron.

Probably the best exposure of the Brush Creek limestone in the whole quadrangle is half a mile east of Eisaman at a tunnel in the bottom of the hill on the north side of Little Sewickley Creek. Here the following section was measured.

Section ½ mile east of Eisaman.

	Ft.	in.
Shale, dark, fine-grained	10	
Limestone, (Brush Creek), fossiliferous, dark, badly weathered	1	
Clay-shale, black		2
Coal, clean	1	2
Shale		7

In the Murrysville region this limestone is missing, but its horizon is represented by a fossiliferous shale occurring just above the Brush Creek coal.

Brush Creek coal. The section given also shows the maximum observed thickness of the Brush Creek coal in the southern part of

the quadrangle. Farmers report it as 3 feet thick near the crop in some of the old openings near Eisamen, but it is thick enough to be worked at only a few points. Its horizon, however, is nearly always marked by black carbonaceous shale or a thin coal. The coal seems to be a much more persistent feature than the limestone above. Certainly it was seen at many more places. It occurs from close beneath to twenty feet below the Brush Creek limestone (when the latter is present) and about 100 to 140 feet above the Upper Freeport coal, the average interval being close to 130 feet. The interval increases from an average of about 120 feet in the northwest, to nearly 140 in the southeast. Drill holes and outcrops have shown the coal to be persistent over practically all of the western half of the quadrangle, and much, if not most, of the eastern half.

The coal crops out and has been mined along the southern part of the Grapeville anticline and in the north along the Murrysville anticline. In the latter region it attains a maximum thickness of three feet.

A clay is usually immediately beneath the coal and then a dark, fissile shale. This shale may occupy the entire interval to the Mahoning coal (or its horizon) or may be replaced in part by the upper part of the Mahoning sandstone.

Mahoning sandstone. The Mahoning sandstone is considered to extend from the Brush Creek horizon down to the Upper Freeport coal. Actually, it seldom occupies more than half that interval. Frequently it is split by the Mahoning coal and where so split, the sandstone above or below the coal is usually replaced to a large extent by shale or sandy shale.

In the Murrysville region the maximum thickness of the Mahoning is about fifty feet. Near Oakford Park (one mile east of Jeannette) 130 feet of sandstone was observed. This tremendous thickness is, of course, unusual and may include the Buffalo sandstone. Commonly the thickness is much less, 50 feet probably being a good average. Usually a shale containing the Mahoning coal horizon occurs between the massive sandstone beds. The whole Mahoning member is quite variable and may contain limestone and clay as well as the sandstone and shale already mentioned. It is not unusual for drillers to report a limestone beneath the Mahoning coal, although such an occurrence was observed only once or twice on the surface.

In the northeast, where the Saltsburg sandstone is so well developed, the Mahoning is thin and unimportant. In the southeast, it is thick and massive.

Where well developed, as at Oakford Park, the Mahoning is massive bedded and well suited for quarrying as a rough building stone,

for foundations, etc. Since the outcrop is so limited the sandstone cannot obtain a very wide usage in this quadrangle, particularly so as it must compete with similar sandstones which occur above it.

Mahoning coal. This, the lowest coal in the Conemaugh group, occurs 30 to 70 feet above the Upper Freeport coal in the midst of the Mahoning sandstone. It is variable and local in its occurrences. It has a limited outcrop along all three major anticlines but is thick enough to be worked from its outcrop only along the Grapeville anticline, and a small area in the north along Pucketa Creek. At the Smail Bros. mine, $1\frac{3}{4}$ miles northeast of Jeannette the maximum measured thickness of coal was obtained. Three measured sections at this mine are here given:

Sections of Mahoning coal at Smail Bros. mine, $1\frac{3}{4}$ miles northeast of Jeannette.

At outcrop.

	Ft.	in.
Black shale		
Bone and shale	1	0
Coal, soft, sulphur streaks and balls	2	8
Mother of coal	0	$\frac{1}{4}$
Coal	0	$2\frac{3}{4}$
Shale	0	2
Coal, soft	1	1
Fire clay	1	1

Near outcrop.

	Ft.	in.
Carbonaceous shale	3	0
Coal	4	5
Clay-shale	0	3+

100 yards from outcrop.

	Ft.	in.
Shale		
Clay-shale	0	4
Coal	2	10
Clay parting	0	1
Coal	1	1
Clay		

Drill hole records would seem to show that the Mahoning is thick enough to be worked at some future date in the northeast part of the quadrangle also.

The interval between the Mahoning coal and the Upper Freeport coal is occupied by the lower part of the Mahoning sandstone and by shale.

ALLEGHENY GROUP.

The Allegheny group extends from the top of the Upper Freeport coal to the base of the Brookville coal and has in this quadrangle an average thickness of about 285 feet. The only part of this group which outcrops in the quadrangle is the Upper Freeport coal and the clay underlying it. This much of the formation is exposed in Haymakers Run northeast of Murrysville and at Oakford Park east of Jeannette. The rest of the formation is concealed beneath the surface and knowledge of it is derived entirely from drill-hole records and outcrops in adjacent quadrangles.

This group was long known as the "Lower Productive Coal Measures" because of the workable coal beds in it. There are at least four such workable beds in this area. The bulk of the group is composed of sandstone, shale, and limestone beds of variable thickness and extent, like the groups previously described. The thickness of the Allegheny is apparently much more constant than that of the Conemaugh. The first three of the following sections are from records of deep diamond drill bore-holes at the point indicated, the last section given is from the carefully kept record of a churn drill bore-hole.

Section at Rillton, Sewickley township.

	Thickness Ft.	Thickness in.	Total Ft.	Total in.
Coal and partings, Upper Freeport	5	7	5	7
Fire clay	3		8	7
Coal		7	9	2
Shale and limestone	16	6	25	8
Shale, light-colored, sandy	11	6	37	2
Fire clay	4		41	2
Shale, light-colored, sandy	17		58	2
Sandstone	7		65	2
Shale, dark	18		73	2
Slate, black	2	8	75	10
Coal, Lower Freeport		6	76	4
Fire clay	9		85	4
Shale, light-colored	7		92	4
Sandstone	1		93	4
Fire clay	6		99	4
Shale, gray	9		108	4
Slate, black	17		125	4
Sandstone	5	6	130	10
Slate, black	6		136	10
Bone		2	137	
Coal, Middle Kittanning	3	7	140	7
Slate, black	6		141	1
Fire clay	3		144	1
Shale, light-colored, sandy	9		153	1
Sandstone	2		155	1
Shale, dark, sandy	7	7	162	8
Slate, black	13		175	8
Coal, Lower Kittanning	2	10	178	6
Fire clay, hard	3		181	6
Shale, light-colored, sandy	4	2	185	8
" dark, sandy	14		199	8
Sandstone	51		250	8
Shale, dark, sandy	21	6	272	2
Fire clay, Lower Clarion	4		276	2
Shale, gray	9		285	2
Slate, black	3	6	288	8
Coal, Brookville		10	289	6

Section at Biddle, North Huntingdon township.

	Thickness Ft.	Thickness in.	Total Ft.	Total in.
Bone, Upper Freeport coal horizon		2		2
Limestone and sandy shale	5	4	5	6
Fire clay and limestone	3	11	9	5
Shale, light-colored, and limestone	2	6	11	11
Shale, light-colored	10		21	11
" light-colored, sandy	3	5	25	4
" gray	4	4	29	8
Bone		4	30	
Fire clay	8	3	38	3
Shale, light-colored, sandy	8	11	47	2
Slate, black		3	47	5
Shale, light-colored, sandy	3	7	51	
" dark, sandy	12	6	63	6
" dark	3		66	6

FIGURE 5. Area in red underlain by upper Freeport coal.

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Section at Biddle, North Huntingdon township—Continued.

	Thickness Ft.	in.	Total Ft.	in.
Slate, black	1	3	67	9
Slate and bone. Lower Freeport		7	68	4
Fire clay, hard	6		74	4
Shale, light-colored, sandy	4	7	78	11
Sandstone, micaceous	9	6	88	8
Shale, light-colored		7	89	3
Sandstone	26	2	115	5
Shale, dark (Upper Kittanning coal horizon)		10	116	3
Sandstone	24	4	140	7
Slate, black	7	1	147	8
Bone		10	148	6
Coal, Middle Kittanning	3	8	152	2
Fire clay	7	7	159	9
Shale, light-colored, sandy	9	6	169	3
" dark	4	5	173	8
" light-colored	6	6	180	2
Slate	7	7	187	2
Coal, Lower Kittanning	2	2	189	4
Fire clay	9	8	198	4
Shale, light-colored, sandy	9	4	207	8
Slate, black	23	3	207	11
Coal	7	8	208	7
Fire clay		7	209	2
Bone		3	209	5
Fire clay	6	8	216	1
Shale, light-colored, sandy	13		229	1
" gray	23	4	252	5
" black	7	6	259	11
Coal, upper split of Brookville	1	4	261	3
Fire clay	2		263	3
Shale, light-colored	3		266	3
" dark	6		272	3
Bone		2	272	5
Coal, lower split of Brookville	1	3	273	8

Section at Export, Franklin township.

	Thickness Ft.	in.	Total Ft.	in.
Shale, dark, sandy (Upper Freeport coal horizon?)	9	11	9	11
Sandstone	5	4	15	3
Shale, dark, sandy	6	3	21	6
Fire clay, shaly	1	11	23	5
Shale, light-colored	5	4	28	9
Fire clay	2	11	31	8
Shale, light-colored	33		64	8
" " " sandy	4	6	69	2
Sandstone	36		105	2
" and coal		10	106	
Slate and coal		2	106	2
Sandstone	46		152	2
Slate, black	9	3	161	5
Bone		8	162	1
Coal, Lower Kittanning	2	10	164	11
Fire clay	1	4	166	3
Shale, sandy	23	5	189	8
Sandstone	4	11	194	7
" shaly	15		209	7
"	14		209	7
Bone		2	224	6
Fire clay	15	8	240	2
Shale, light-colored	17	6	257	8
Limestone	3	11	261	7
Slate, black	4	11	266	6
Bone, Clarion coal horizon		3	266	9
Fire clay	4	9	271	6
Sandstone, shaly	9		280	6
Shale, dark, sandy	8	4	288	10
" light-colored	2	7	291	5
Coal, slate and bone Brookville		7	292	
Coal, Brookville		8	292	8

Section at a point a quarter of a mile south of the north boundary of the quadrangle and a mile and three-quarters west of the east boundary.

	Thickness Ft.	Total Ft.
Coal, Upper Freeport	5	5
Slate, white	12	17
Limestone	6	23
Slate, white	10	33
Sandstone	18	51
" dark	5	56
Limestone	9	65
Sandstone	12	77
Slate, white	32	109
" dark	8	117
Coal, Upper Kittanning	2	119
Slate, white	40	159
Sandstone	5	164
Sandstone	8	196
Slate, white	24	188
Slate, dark	32	228
Slate, white	10	238
Slate, dark	16	254
Sandstone, Pottsville		

Upper Freeport coal. The Upper Freeport coal varies greatly in thickness and is less persistent than is commonly thought. Its character also changes from point to point but within limited areas is fairly uniform. In the so-called "Thick Freeport" area in the northwest part of the quadrangle the coal is usually marked by two thin shale partings near its base. It ordinarily is low in ash and sulphur and consequently is valued highly. It is mined in the northwest corner of the quadrangle and at Oakford Park, near Jeannette. The following sections are typical of the coal in those areas:

Section at Oakford Park, 1¼ miles east of Jeannette.

	Ft.	in.
Sandstone, Mahoning	5+	
Shale, black	5	1
Coal, Upper Freeport	2	8
Fire clay		

Diamond drill-hole section, ¾ mile west of Sardis, Franklin township.

	Ft.	in.
Slate, black	6	1
Coal	2	10
" bony		8
"	3	
Slate		1
Coal		10
Fire clay		

Diamond drill-hole section, ½ mile east of New Texas, Plum township.

	Ft.	in.
Slate, dark	1	
Coal	3	2
" bony		8½
"	3	3
Slate		1
Coal		10½
Fire clay		

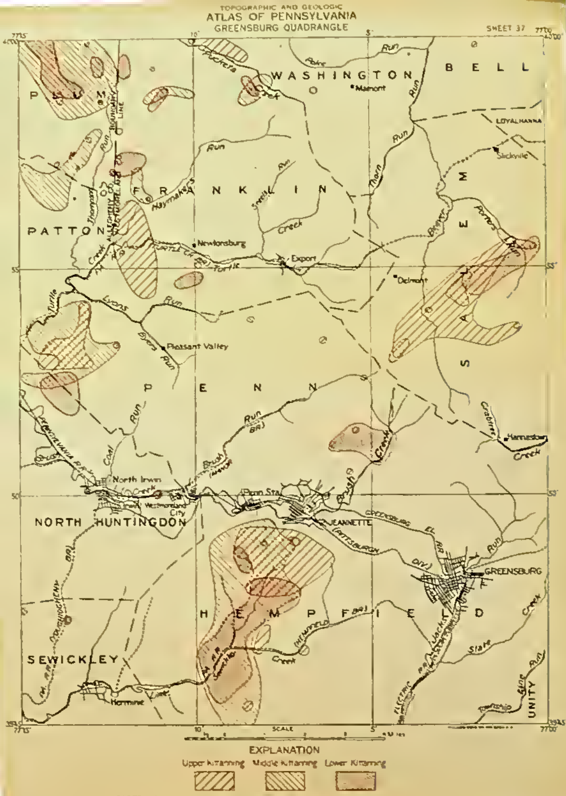

FIGURE 6 Areas known to be underlain by the Kittanning coals, based chiefly on churn drill-hole records.

A few miles southeast of the above drill-holes the Upper Freeport coal crops out in Haymakers Run. In this short distance the coal has thinned greatly and changed otherwise in character.

Typical section on Haymakers Run.

	Ft.	in.
Clay-shale	5	0
Carbonaceous shale	0	5
Coal, thin shale partings	3	2
Fire clay	4	0

Drill-holes scattered over the quadrangle have delimited the Upper Freeport fairly well and the accompanying sketch map (figure 5) shows its approximate boundaries. It is evident that the swamp in which was laid down the carbonaceous material which later formed the Freeport coal, was not nearly so widespread as that in which the Pittsburgh coal had its origin. Humps and depressions in this earlier swamp may account for the great thickness of the coal in certain areas and its entire absence in others. In spite of this erratic occurrence the Upper Freeport coal is the third most valuable coal in the quadrangle.

The most constant of the Allegheny coals are the Upper Freeport, Upper Kittanning, Middle Kittanning, and Lower Kittanning. The Kittanning coals underlie large areas and without a doubt will some day also be worked. The Middle Kittanning is the most persistant and has been noted in drill-holes throughout much of the quadrangle. Fig. 6 shows the areas underlain by the Kittanning coals as determined from drill-holes. Since few holes have been put down in the synclines, evidence is lacking as to whether the coals are present there or not. Judging from their continuity along the anticlines they probably are. From the evidence at hand it is believed that the Middle Kittanning coal underlies most of the western half of the quadrangle.

The rest of the Allegheny group is made up predominantly of sandstones and shales.

Pottsville Series.

The Pottsville series is considered to extend from the base of the Brookville coal to the top of the red beds of the Mauch Chunk series. In this region it consists largely of sandstone with some shale and an occasional thin coal, clay, or limestone. (See Plate X). The Homewood sandstone in the upper part of the series is the most prominent and persistent feature, although the Mercer shale horizon is equally persistent. The Pottsville averages about 180 feet in thickness in the Greensburg quadrangle.

Mauch Chunk Series.

The Mauch Chunk series in this area is merely a thin wedge of limestone and shale, thicker towards the east, and thinning out

altogether toward the northwest. The Greenbrier limestone, a part of the series, was noted in comparatively few drill-holes, not one in four of the records which show the red shale, mentioning the limestone. This may mean that the limestone is not nearly so wide-spread as the red shale, or it may represent carelessness on the part of the drillers. Probably the truth lies somewhere between these two extremes.

The top of the Mauch Chunk red shale lies at an average distance of 1115 feet below the base of the Pittsburgh coal in this quadrangle, the distance increasing slightly from northwest to southeast. The thickness of the series ranges from a thin film to slightly over 100 feet. In large areas it is entirely lacking from the stratigraphic section. The accompanying sketch map (Figure 7) shows the area underlain by the Mauch Chunk series as determined from drill-hole records.

Pocono Series.

The Pocono series, the base of the Mississippian system, in this area is predominantly sandy and contains several of the so-called oil and gas "sands." The thickest of these is the Big Injun, at the top of the series, which corresponds to the Burgoon sandstone and is over 300 feet thick. The Berea sandstone is at the base of the series. Between these two sandstones are found thin sandstones alternating with shale and occasionally a thin band of the Patton red shale. The average thickness of the Pocono as determined from drill-hole records is about 700 feet. The character of the Pocono series and of the underlying Devonian rocks is shown in Plates VIII, IX, X, in which typical records of drill-holes spaced at intervals diagonally across the entire quadrangle have been plotted.

GEOLOGIC STRUCTURE.

DEFINITION OF STRUCTURE.

Structure is defined[8] as "that part of the geology of a region which pertains to the attitude of the rocks, the nature and amount, if any, of the deformation which they have undergone, and the distribution and mutual relations of the structural features." When first formed, sedimentary beds are practically horizontal, but diastrophism, or movements which warp the earth's crust, twist, break and contort them so that today the exposed sedimentary beds are seldom horizontal. In Pennsylvania this is particularly true. In the eastern part of the State sedimentaries are broken and sharply tilted and in large measure have been metamorphosed by the heat and pressure to which they have been subjected. In western Pennsylvania the rocks apparently have been subjected to less pressure

[8] Fay, A. H., A Glossary of the mining and mineral industry: U. S. Bureau of Mines Bull. 95, 1920.

FIGURE 7. Area in red underlain by Mauch Chunk series.

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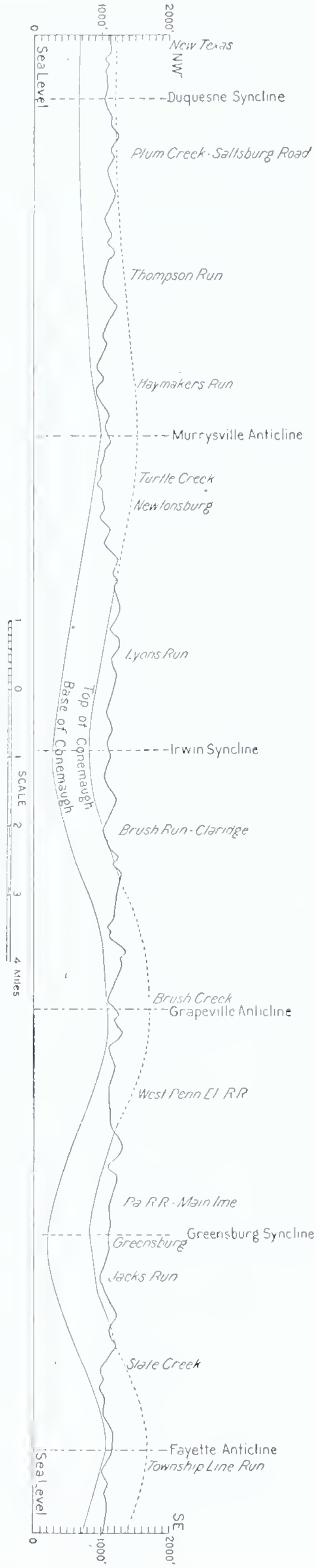


Fig. 8. Cross section of the Greensburg quadrangle, northwest to southeast.

and the folding and faulting of the strata is much less pronounced. The decrease in the intensity of folding from east to west in the Greensburg quadrangle is quite marked. It is easy to observe this feature from the windows of a Pennsylvania Railroad train as it passes through the cuts on the way from Greensburg to Pittsburgh.

Faulting in the Greensburg quadrangle is known at only a few isolated points. The faults are of such small throw—a few inches only—as hardly to warrant the name. In every case the effect on the "lay" of the beds is negligible.

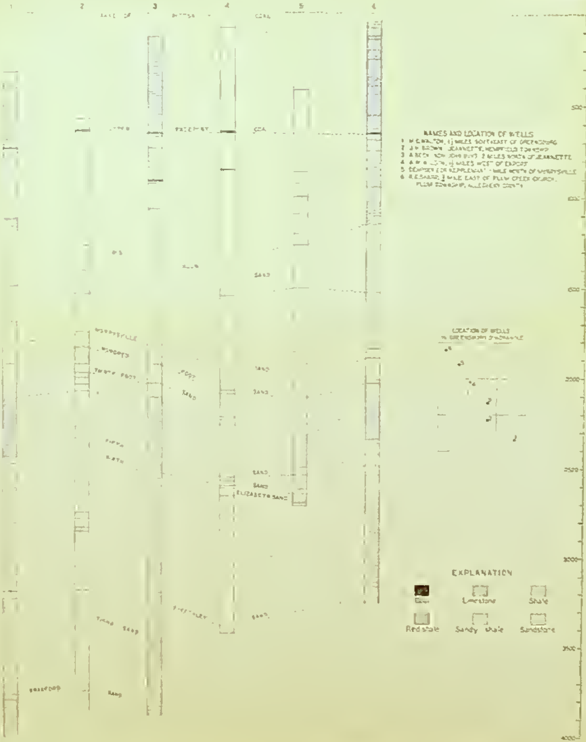
REPRESENTATION OF STRUCTURE.

The structure of a region is usually shown by means of cross-sections and by structure contour lines. A sketch cross-section of the quadrangle from northwest to southeast (see Fig. 8) shows the increase in the intensity of folding towards the Allegheny Mountains. The vertical scale is five times the horizontal in order to bring out the folding, which in this area is too gentle to show plainly without exaggeration.

A better method of showing gentle structures is by the use of structure contour lines. Such contour lines are similar to topographic contour lines in that all points on any one line are at the same elevation above or below some specified datum plane, usually mean sea level. They differ from topographic contour lines in that they show the configuration, or hills and valleys, of some selected stratum regardless of whether that stratum is exposed at the surface, is concealed beneath the surface, or perchance has been eroded. At points where the structure contour lines and the topographic contour lines have the same elevation the selected stratum upon which the structure has been drawn must outcrop. By varying the contour interval to suit the need this method is applicable to all except very steep structures and is an easy way of showing eccentricities and irregularities of structure such as are common in areas of gentle folding.

METHOD OF MAPPING.

Choice of stratum to use as a base. The stratum chosen as a base for mapping structure is dependent upon several factors, chief of which are length of outcrop and ease of recognition in the field. No other stratum fulfilled these conditions so well as the Pittsburgh coal. This bed outcrops over a wide area, is easily recognized, and furthermore, has been used in adjacent quadrangles as the base for mapping structure. For these reasons there was no question as to the choice of a base—the Pittsburgh coal was pre-eminently the best stratum to use.



Sections of a series of wells extending from the southeast to the northwest corner of the quadrangle.

Key horizons used. Since the Pittsburgh coal underlies some areas and is eroded in others, it is necessary, in order to map the position of the coal, to determine the intervals between the Pittsburgh coal and certain persistent "key" rocks above and below it. These rocks having been identified on the surface and the interval to the coal being known, it is then possible to figure the correct elevation of the coal. Such "key" rocks or "key" horizons are most valuable when they are most persistent and when their interval to the Pittsburgh coal remains fairly constant. In the Greensburg quadrangle the elevation of the coal in the synclines has been determined largely by mine surveys and hence it was more important to have key horizons below the coal in order to determine the elevation of the Pittsburgh coal horizon at points where the coal had been eroded. Fortunately a very constant stratum, the Ames limestone, is found about 300 feet beneath the coal. This stratum was mapped wherever it outcropped and by determining the intervals between it and the Pittsburgh coal at various points throughout the quadrangle, it was possible to depict the structure over large areas where the coal had been eroded.

Probable errors. None of the strata below the Ames and outcropping in the quadrangle are very constant in their character or occurrence and as a consequence in those areas in which both the Pittsburgh coal and the Ames limestone have been eroded, the structure is more likely to be inexact than in the remainder of the quadrangle. In such areas, along the axes of the anticlines, it was necessary to determine the structure from thin coals, variable sandstones and thin, local limestones. It is hoped nevertheless that the structure as shown is within 25 feet of being correct at any and all points in the quadrangle.

DESCRIPTION OF STRUCTURE.

In conformance with the general structure of midwest Pennsylvania, the rocks in the Greensburg quadrangle are folded into long anticlines and synclines having a northeast-southwest trend. (See Plate XI). Viewed broadly these anticlines and synclines are quite regular in appearance. Detailed work shows, however, that the structures have many kinks and humps and that the axes of the structures are only approximately parallel. Plane-table work doubtless would prove the existence of many minor kinks on the flanks of the folds, and other irregularities which it is impossible to detect without the use of accurate instruments.

As shown in Fig. 8 the folds increase in sharpness from west to east. The various structures have been named from towns through which they pass and are (in a west-east order) named as follows: Duquesne syncline, Murrysville anticline, Irwin (Port Royal) syncline, Grapeville anticline, Greensburg syncline, and Fayette anti-

cline. The Elders Ridge syncline is simply a continuation of the Irwin syncline and had been named previously.

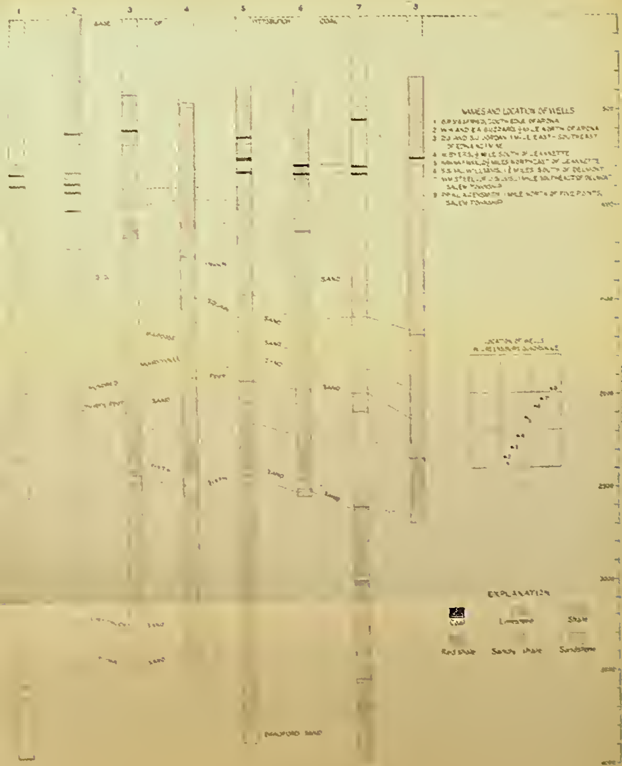
The various structures are described in order from northwest to southeast.

Duquesne syncline. This syncline, originating as a branch of the Pigeon Creek syncline, passes through Dravosburg and Duquesne, follows up Thompson Run and enters the Greensburg quadrangle three-fourths of a mile northeast of Trestle. It crosses the northwest corner of the Greensburg quadrangle as a broad shallow basin. The axis pursues a general northeast course between the village of New Texas and Plum Creek Church.

Murrysville anticline. Tremendous quantities of gas obtained from this anticline in the past have made it known to everyone in this region who is interested in the production of oil and gas. The supply of gas is by no means exhausted even now. The anticline passes through West Elizabeth, Clairton, Belle Ridge, and Versailles and enters the Greensburg quadrangle about one mile southeast of Trafford City station of the Pennsylvania Railroad. The axis passes about half a mile east of Murrysville (from which place the anticline gets its name) and continues in a northeasterly direction. The Murrysville anticline is strongly developed in the Greensburg quadrangle. It increases in elevation to the northeast and raises the Pittsburgh coal horizon (the coal has been eroded) from 1280 feet above sea level at the west boundary of the quadrangle to over 1800 feet at the north boundary.

Irwin (Port Royal) syncline. The Port Royal syncline, known to bituminous coal operators as the Irwin basin, has its greatest development in the Greensburg quadrangle. The axis of this syncline passes one quarter of a mile west of Herminie, through Westmoreland City and Manor, half a mile west of Harrison City and one mine east of Export. The whole structure pitches to the southwest or in other words the bottom rises from the south of Herminie where the Pittsburgh coal is well below the surface and is less than 600 feet above sea, to the vicinity of Export where its elevation is 950 feet. Northeast of Export the structure rises much more rapidly and the Irwin basin proper can be said to end three or four miles northeast of Export. Here the Pittsburgh coal crops out and in the saddle between the Irwin basin and the Elders Ridge syncline most of the coal has been eroded.

The Elders Ridge syncline, the south end of which is in the Greensburg quadrangle, is a continuation of the Irwin syncline as both lie between the Murrysville and the Grapeville anticlines. The Elders Ridge syncline has a low pitch to the northeast and the Pittsburgh coal sinks from an elevation of 1250 feet at the mouth of Porters Run to 1170 feet at the quadrangle boundary.



Sections of a series of wells extending from southwest to northeast along the Grapeville anticline.

Grapeville anticline. This structure also is well known to oil and gas men. It has produced tremendous quantities of gas in the past and still is a large producer. Part of the structure has not yet been tested by the drill. The south end of this anticline is just north of Walts Mill on Sewickley Creek. The crest rises rapidly and one mile southeast of Arona the horizon of the Pittsburgh coal is at an elevation of 1460 feet. From this point the axis extends northeast through Eisaman, swings more to the east and passes through Grapeville, cuts the main line of the Pennsylvania Railroad about one mile east of Jeannette station, inclines slightly more to the east and passes directly through the village of Five Points. The highest part of the anticline is a dome about three and one-half miles northeast of Jeannette. Here the horizon of the Pittsburgh coal is more than 1800 feet above sea level. Northward the elevation of the Pittsburgh coal horizon decreases 150 feet in four miles. Another dome occurs just south of Grapeville and undoubtedly is responsible for the good gas field there.

Greensburg syncline. The Greensburg basin has long been known to coal operators as one of the four great coal basins of western Pennsylvania. The city of Greensburg is in the middle of the basin and owes its existence largely to the valuable Pittsburgh coal bed underneath it.

The south end of the Greensburg syncline is just east of the tip of the Grapeville anticline. The axis of the syncline crosses the Greensburg quadrangle in a northeast direction, passing through Swede Hill and the city of Greensburg, and leaving the quadrangle one mile east of Hannastown. At the bottom of the basin, two miles north of Greensburg, the Pittsburgh coal is 775 feet above sea level. East of Hannastown the coal has risen to 830 feet. Southwest of Greensburg the structure rises rapidly. The horizon of the coal—the coal has been eroded—along the axis of the syncline at the south boundary of the quadrangle is at an elevation of 1250 feet.

Fayette anticline. The Fayette anticline, like the Duquesne syncline, crosses only a quarter of the quadrangle. The axis of the anticline has a northeast-southwest trend and is close to the Hempfield-Unity township line. The anticline rises sharply from south to north.

The anticlines and synclines described above and shown on Plate XI, constitute the major structural features of the quadrangle. There are minor kinks and folds in the synclines and on the anticlines which are of local importance only. Most of these it is impossible to show on the structure sheet on account of the large contour interval which it was found necessary to use.

STRUCTURE OF THE MURRYSVILLE SAND.

In addition to the structure map based upon the Pittsburgh coal, a map has been drawn to show the structure of the Murrysville sand (Fig. 9). * In order to bring out the relation between the folds at this horizon and the folds of an outcropping stratum, contours drawn on the base of the Pittsburgh coal were superimposed upon the same map. The map shows clearly that the crest of the Grapeville anticline at the lower horizon is several hundred feet farther east than at the surface. This is a matter of great importance in considering the location of wells. It also partly explains why drilling on the west side of the anticline (as located on the surface) has been much more successful than drilling on the east side.

The structure lines in the upper, left-hand part of the map show a flattening of the rocks in the Duquesne syncline in such a way as to form a terrace. This probably accounts for the local occurrence of oil pools in the Hundred-foot and Speechley Stray sands, since it has been repeatedly shown that such a change in dip tends to trap any oil that may be moving through the sand.

MINERAL RESOURCES.

The most valuable mineral in the Greensburg quadrangle is coal. Natural gas is second in importance, and oil, limestone, shale, sandstone, and clay trail far in the rear.

COAL.

For the sake of convenience the coal beds will be described in descending stratigraphic order, omitting coals of no economic value.

Since the coals were described rather fully under "Stratigraphy", the following descriptions will be short, greater emphasis being given to detailed sections of the coals in different areas. The tonnage statistics[8] are subject to correction, the figures given having been derived in most cases from incomplete data. The reliability of the tonnage estimates for the different beds decreases in the following order: Pittsburgh, Redstone, Waynesburg, Upper Freeport, Lower Kittanning, and Middle Kittanning. Thus, although the figure given for the Pittsburgh coal are fairly accurate, those for the Kittanning coals are only approximate.

In figuring the recoverable tonnages, a percentage factor, denoting the mined portion of the coal, and a mining loss factor, were both deducted from the estimated tonnage figures of the original deposit.

*It perhaps is well to explain that the structure of the Murrysville sand was drawn independently of the surface structure. The structure of the Pittsburgh coal was determined from elevations of outcrops of the coal and of other "key" horizons. That of the Murrysville sand was drawn by determining the elevations of all wells located, and subtracting the elevation of the mouth of each well from the depth to the top of the Murrysville sand as recorded in the log of the well; points of equal elevation then being connected by contour lines.

[8] Reese, J. F., Coal reserves in Westmoreland County, Penna.: Pa. Geol. Surv. Bull. No. 35, 1922.

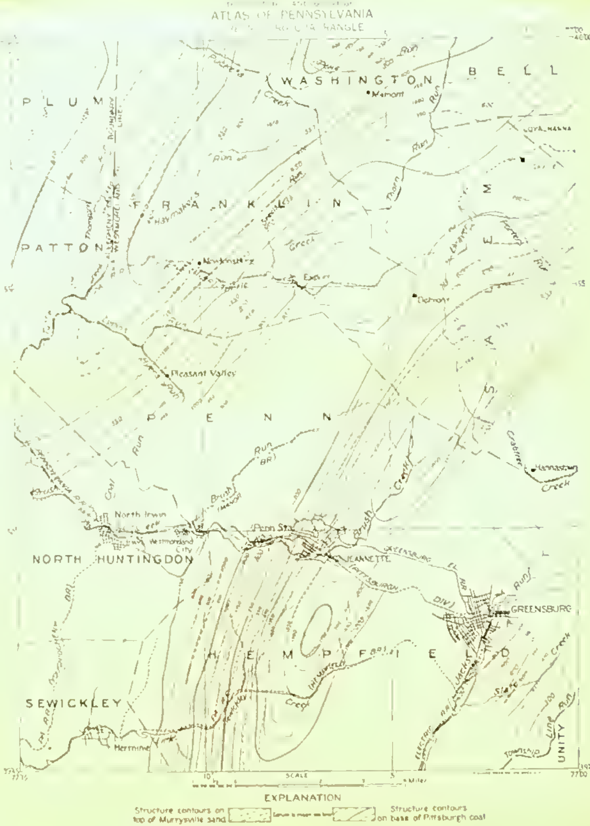


FIGURE 9. Structure contours on Murrysville sand and Pittsburgh coal.

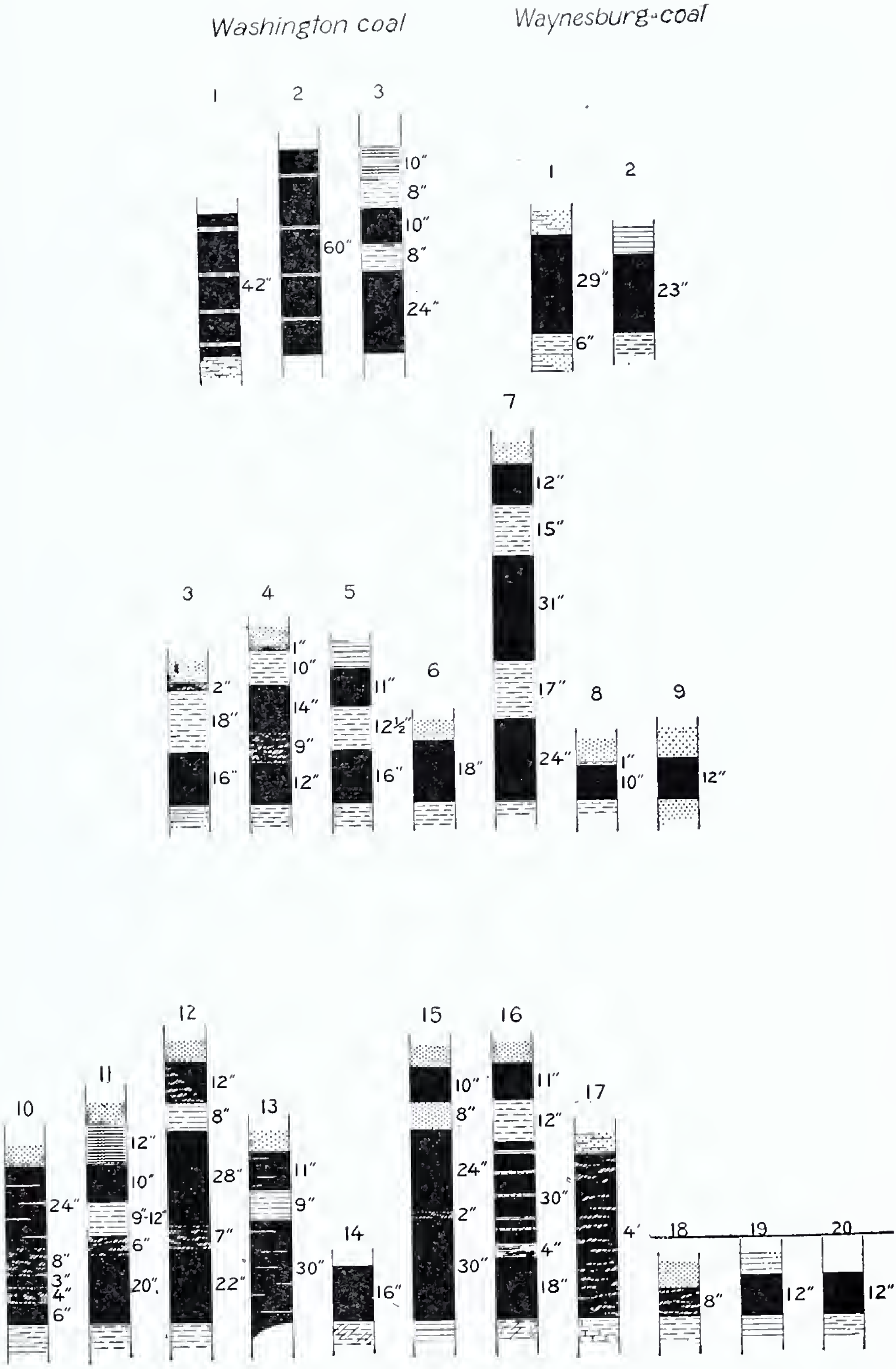


Fig. 10. Sections of Washington and Waynesburg coals.

These factors were determined by general mining practice within the various fields.

Washington coal. The Washington coal occurs only in small isolated patches in the tops of some of the higher hills in the Irwin syncline. This coal bed invariably contains many shale partings and usually has so little covering that it is badly weathered (See Fig. 10).

Waynesburg coal. The Waynesburg coal occurs in both the Irwin and Greensburg synclines, but is of workable thickness only in the former. In the Irwin basin a few isolated patches of the coal occur north of the main line of the Pennsylvania Railroad, but as shown in the sections it is hardly thick enough and it is certainly not extensive enough north of the railroad to warrant mining it. The coal is of better quality and is thicker south of the railroad where it has been mined at many points. The outcrops and extent of the Waynesburg coal are shown on the economic geology map, Plate XI.

The localities where the sections in Figure 10 were measured are described below.

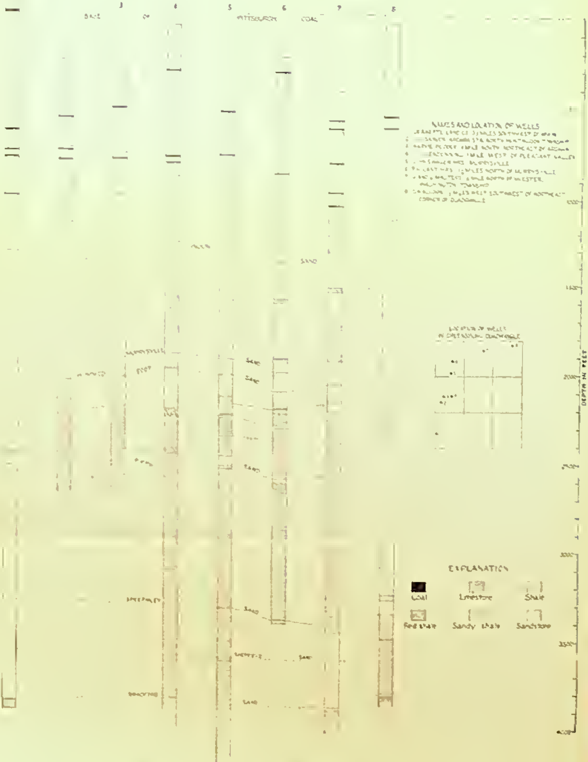
WASHINGTON COAL.

1. Outcrop near BM 1167, 1½ miles east of Chambers, North Huntingdon township.
2. Country bank. (abandoned), 1 mile east of Rillton, Sewickley township. Thickness shown as reported by farmer—not measured.
3. Outcrop, 1 mile east of Chambers, North Huntingdon township.

WAYNESBURG COAL.

1. Outcrop, near BM 1238, 1 mile southeast of Circleville, North Huntingdon township.
2. Outcrop, 1 mile northwest of Rillton, Sewickley township.
3. Outcrop, ¼ mile northwest of BM 1028 at Rillton, Sewickley township.
4. Outcrop at north end of P. R. R. tunnel and ½ mile south of Lindencross (now Cereal), North Huntingdon township.
5. Country bank, abandoned, ½ mile north of Herminie, Sewickley township.
6. Outcrop, ¼ mile southwest of section 5.
7. Herminie mine, Fairhaven Coal Company, ½ mile east of Herminie, Sewickley township.
8. Outcrop, ⅜ mile southwest of BM 1052 at Herminie, Sewickley township.
9. Outcrop, 1 mile north of Herminie, Sewickley township.
10. Country bank, 200 yards west of Edna No. 2 mine, Hempfield township.
11. Country bank, J. Lintner farm, 1 mile south of Edna No. 2 mine, Hempfield township.
12. Howell mine, Evanston Coal Company, 1 mile north-northeast of BM 1052 at Herminie, Sewickley township.
13. Country bank, ¼ mile north of BM 938 near Darragh (now Madison Station) Hempfield township.
14. Outcrop, ¼ mile northeast of BM 1165, near Edna No. 2 mine, Hempfield township.
15. Edwards No. 4 mine, Edwards Coal Company, 1½ miles northeast of Herminie, Sewickley township.
16. Herminie mine, Fairhaven Coal Company, ½ mile east of Herminie, Sewickley township.
17. Outcrop, near BM 1136, 1 mile west of Harrison City, Penn township.
18. Outcrop, ½ mile southwest of BM 1032 near Claridge, Penn township.
19. Outcrop, between BM 1212 and BM 1204, 1½ miles south of Export.
20. Outcrop, ½ mile northeast of BM 1108 and 2 miles north-northeast of Greensburg.

As shown by the sections, Fig. 10, the Waynesburg coal is characterized by several shale partings. The coal is of rather poor quality, running about 3 per cent sulphur and 20 per cent ash. Near Herminie



Sections of a series of wells extending from southwest to northeast along the Murrysville anticline

where it is best developed, the coal is blocky and of medium hardness. Elsewhere it is apt to be rather soft. The following analyses of samples taken in the fall of 1921 illustrate its character.

Analyses of Waynesburg coal.

(H. M. Cooper, U. S. Bureau of Mines, analyst.)

Locality	Sample No.	Proximate, as received		Ultimate, as received		Calorific value	
						Calories	B. t. u.
Edwards No. 4 mine, Edwards Coal Co., 1½ miles northeast of Herminie	Composite 81159	Moisture Vol. matter Fixed carbon Ash	2.97 22.01 43.94 21.08 100.00	Hydrogen Carbon Nitrogen Oxygen Sulphur Ash	4.76 61.26 1.31 8.44 3.15 21.08 100.00	6,204	11,167
Herminie mine, Fairhaven Coal Co., ½ mi. east of Herminie	Composite 84666	Moisture Vol. matter Fixed carbon Ash	3.60 31.10 46.40 18.90 100.00	Hydrogen Carbon Nitrogen Oxygen Sulphur Ash	4.80 63.50 1.40 8.60 2.80 18.90 100.00	6,369	11,460

During the war and the boom days that followed, the coal was mined on a fairly large scale, but since that time production has dropped to a very small figure. Much of the coal is used locally.

Tonnage Statistics of Waynesburg Coal.

	Short tons.
Total original deposit	15,822,000
Mined	810,000
Reserve	15,012,000
Recoverable	7,600,000

Bench coal. This coal, occurring in the "bench" sandstone of the Benwood member, is of mineable thickness at only one locality in the whole quadrangle - namely, near Adamsburg, Hempfield township. At other points where the bed was seen it proved to be thin and shaly. The sections (Fig. 11) illustrate its changing character.

The analysis of a sample taken at the above-mentioned country bank shows that with careful picking the coal would not necessarily run too high in sulphur or ash to be marketable.

Analysis of Bench coal.

(H. M. Cooper, U. S. Bureau of Mines, Analyst.)

Locality	Sample No.	Proximate, as received		Calorific value	
				Calories	B. t. u.
County bank, J. L. Meyers farm, ½ mile west of Edna No. 1.	84738	Mositure Volatile matter Fixed carbon Ash Sulphur	3.0 34.2 49.1 13.7 100.0 3.6	6,883	12,390

Sections of the "Bench" coal shown in Figure 11 were measured at the places listed below.

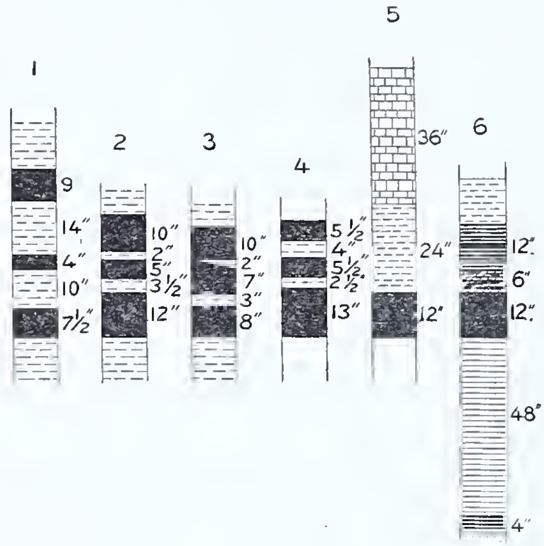


Fig. 11. Sections of Bench coal.

1. Country bank, J. L. Meyers, ½ mile west of Edna No. 1, Hempfield township. Section measured 25 feet from entrance, right rib.

2. Same. Section measured 50 feet from entrance, face of heading.

3. Same. Section measured 50 feet from entrance, right rib.

4. Same. Section measured 50 feet from entrance, left rib.

5. Prospect entry, ½ mile west of Darragh, Hempfield township.

6. Outcrop, behind Norwin High School in Irwin, North Huntingdon township.

As yet there has been practically no production and it is impossible that there could ever be more than a very small production of coal from this source.

Redstone coal. One of the important coals in the Greensburg quadrangle and one which in the past has been mined extensively is the Redstone coal. Outcropping (where present) in much of the territory south of the main line of the Pennsylvania Railroad, the Redstone in this area is easily accessible. Because of this fact and its thickness (three feet or more in much of this area) and good qualities, the Redstone is well thought of. Its greatest drawback is the prevalence of clay and sandstone "horsebacks". These are unfortunately quite common. Where well developed the coal is hard, blocky and bright, with few, and often no clay partings. The roof is either shale or massive sandstone, usually the former. The floor almost everywhere is clay.

North of the railroad the Redstone has been mined at only one point, a country bank north of Penn Station. South of the railroad it has been mined chiefly near Madison and in the Greensburg basin. The incomplete outcrop of the Redstone is shown on Plate XI.

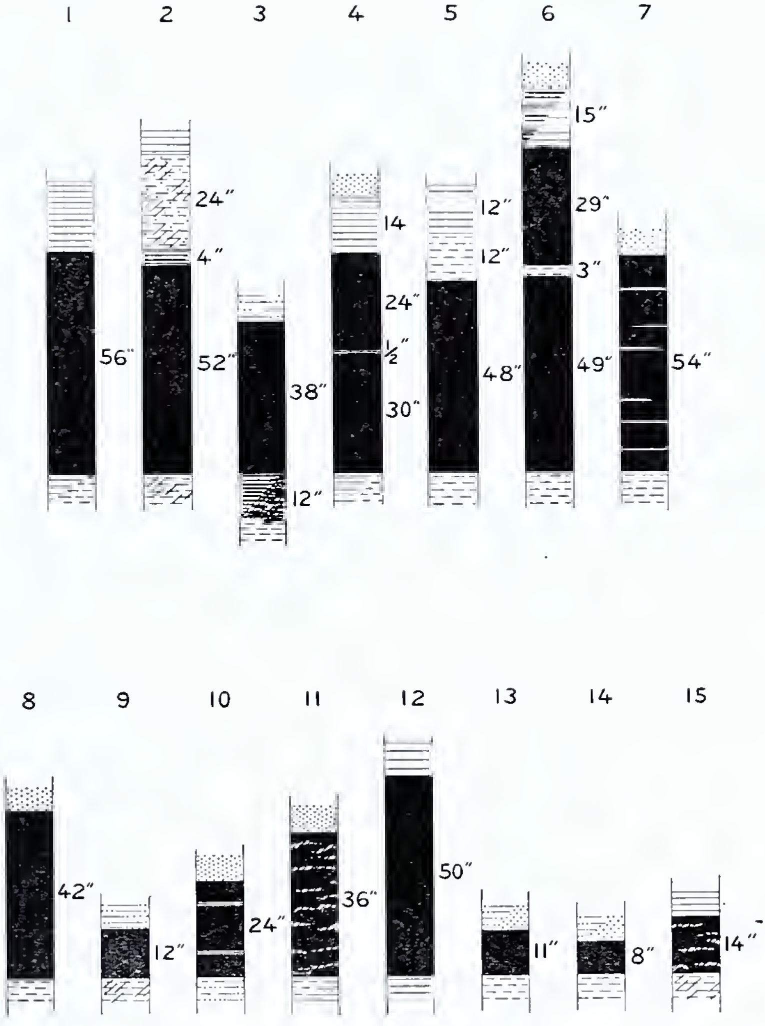


Fig. 12. Sections of Redstone coal.

Sections of the Redstone coal shown in Fig. 12 were measured at the following places:

1. Outcrop in railroad cut, ½ mile south-southeast of Carbon, Hempfield township.
2. Outcrop at quarry of Keystone Clay Products Company, ¼ mile north of Huff, Hempfield township.
3. Outcrop along Lincoln Highway, ½ mile southeast of Radebaugh, Hempfield township.
4. Outcrop, 400 yards east of east end of Radebaugh tunnel, Pennsylvania railroad.
5. Country bank, ¾ mile west-southwest of Dick, Sewickley township, and just beyond western boundary of quadrangle.
6. Country bank, abandoned, 1½ miles south of Darragh, Hempfield township.
7. Abandoned mine, 1¼ miles south of Madison Station, Hempfield township.
8. Outcrop in village of Darragh, Hempfield township.
9. Outcrop, ½ mile northwest of Paintertown, Penn township.
10. Outcrop, hill on east side of Coal Run, and opposite North Irwin, North Huntingdon township.

11. Outcrop, ½ mile northeast of BM 1023, Paintertown, Penn township.
12. Adamsburg mine, Edward Tomajko, ½ mile south of Adamsburg, Hempfield township.
13. Outcrop, ½ mile north-northwest of Sloan, Salem township.
14. Outcrop, ¼ mile southwest of BM 982 at Export, Franklin township.
15. Outcrop, ½ mile northeast of BM 960 at Pleasant Valley, Penn township.

As shown in the following analyses the Redstone is moderately low in ash and sulphur and is suitable for most purposes. For comparison, analyses of samples taken in nearby districts are also given.

Analyses of Redstone coal.

(H. M. Cooper, U. S. Bureau of Mines, analyst)

Locality	Proximate, as received		Ultimate, as received		Calorific value	
					Calories	B. t. u.
Adamsburg mine Edward Tomajko, ½ mile south of Adamsburg	Moisture	2.4	Hydrogen	5.2	7,407	13,340
Sample No.	Vol. matter	34.2	Carbon	74.6		
Composite 84160	Fixed carbon	54.4	Nitrogen	1.4		
	Ash	9.0	Oxygen	8.3		
		100.0	Sulphur	1.5		
			Ash	9.0		
				100.0		
Betty mine, Eisman Coal Co., 1 mile south of Madison	Moisture	2.2	Hydrogen	5.0	7,206	12,970
Sample No.	Vol. matter	35.0	Carbon	72.5		
Composite 84157	Fixed carbon	51.8	Nitrogen	1.5		
	Ash	11.0	Oxygen	6.2		
		100.0	Sulphur	3.8		
			Ash	11.0		
				100.0		
Hilltop mine, Swede Hill South of Greensburg	Moisture	2.11	Hydrogen	5.0	6,892	12,567
Sample No.	Vol. matter	32.08	Carbon	69.33		
Composite 81071	Fixed carbon	51.16	Nitrogen	1.42		
	Ash	14.65	Oxygen	6.19		
		100.00	Sulphur	3.41		
			Ash	14.65		
				100.00		
Hilltop mine, Swede Hill, South of Greensburg	Moisture	2.0	Hydrogen	5.2	7,511	13,520
Sample No.	Vol. matter	34.7	Carbon	74.4		
Composite 85343	Fixed carbon	54.1	Nitrogen	1.5		
	Ash	9.2	Oxygen	6.8		
		100.0	Sulphur	2.9		
			Ash	9.2		
				100.0		
Liberty mine, Liberty Coal Co.; ¾ mile northeast of Smithton, South Huntingdon Twp.	Moisture	2.2	Hydrogen	5.2	7,367	13,260
Sample No.	Vol. matter	33.3	Carbon	73.9		
Composite 85324	Fixed carbon	54.6	Nitrogen	1.6		
	Ash	9.9	Oxygen	7.5		
		100.0	Sulphur	1.9		
			Ash	9.9		
				100.0		
King mine, H. C. Frick Coke Co.; 1 mile southwest of Mount Pleasant	Moisture	1.7	Hydrogen	4.8	7,222	13,000
Sample No.	Vol. matter	31.9	Carbon	72.2		
Composite 85330	Fixed carbon	53.6	Nitrogen	1.4		
	Ash	12.8	Oxygen	6.3		
		100.0	Sulphur	2.5		
			Ash	12.8		
				100.0		

The Redstone, like the Waynesburg, was exploited largely during the war and the two following years, and it is probable that the cream of the production has already been skimmed. The coal is used locally and is also shipped.

Tonnage of Redstone coal.

	Short ton
Original deposit	76,032,000
Mined	1,674,000
Reserve	74,358,000
Recoverable	37,900,000

Pittsburgh coal. This, the most important coal of the bituminous coal fields, had originally a very wide extent. Its persistency, both of occurrence and character, is truly remarkable. Fig. 3, page 38 shows the tremendous area underlain by it. The coal is of uniformly good quality and is characterized throughout the Greensburg quadrangle by its thickness, the ever-present roof coals above the main bed, and certain persistent shale partings in the latter. It is found throughout the quadrangle except where erosion has removed it. (See Plate XI for outcrop and areal extent).

The coal is bright, fairly hard, and breaks in good-sized cubical blocks. The top inch or two of the coal is frequently bony and hence is discarded. The bottom coal is often a little high in sulphur and in years past was often discarded or, rather, not mined. Nowadays the whole bed is usually taken out. The floor is generally a hard fire clay, although in places the coal rests directly on limestone. Fig. 13 is a generalized section of the Pittsburgh coal with the names that are usually applied to the different divisions or benches.

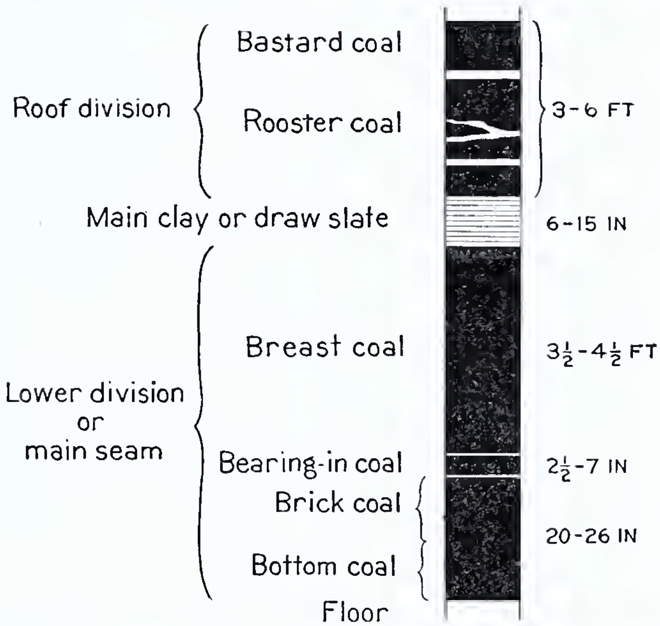


Fig. 13. Generalized section of the Pittsburgh coal bed in the Greensburg quadrangle.

The very thin parting shown between the brick and bottom coal often is not present. The partings above and below the bearing-in bench, however, nearly always are present and are easily seen in

even a hasty examination of any exposure of the coal. The divisions of the generalized section hold for most of the quadrangle, but towards the northeast the section changes slightly with the appearance of additional partings and a thicker band of bony coal near the top. The coal is thinnest in the southwest and thickens towards the north and east. Fig. 14 shows measured sections of the Pittsburgh coal in different parts of the quadrangle.

1. Country bank, ½ mile southwest of New Texas, Plum township.
2. Country bank, ½ mile east of Plum Creek Church, Plum township.
3. Stripping operations, 1 mile west of Plum Creek Church, Plum township.
4. Country bank, James McJunkin, 1 mile south of Plum Creek Church, Plum township.
5. Mine No. 4, Irwin Gas Coal Company, 1¼ miles northeast of Sloan, Salem township.
6. Same as last, different part of mine.
7. Mine No. 3, Irwin Gas Coal Company, ¾ mile north of Sloan, Salem township.
8. Same as last, different part of mine.
9. No. 1 drift, Slickville mine No. 91, Bethlehem Mines Corporation, ¾ mile north-northwest of Sloan, Salem township.
10. No. 2 drift, Slickville mine No. 91, Bethlehem Mines Corporation.
11. No. 3 drift, Slickville mine No. 91, Bethlehem Mines Corporation.
12. Mine No. 5, Irwin Gas Coal Company, 1¼ miles west-northwest of Sloan, Salem township.
13. Mine No. 3, Edwards Coal Company, 1½ miles west of Sloan, Salem township.
14. Mine No. 4, Delmont Gas Coal Company, 1½ miles west of Sloan, Salem township.
15. Mine No. 6, Delmont Gas Coal Company, 2 miles north of Delmont, Salem township.
16. Stripping operation, 2¼ miles north of Delmont, Salem township.
17. Country bank, 1 mile north of Delmont, Salem township.
18. Mine No. 3, Delmont Gas Coal Company, 500 feet east of Delmont Station of Turtle Creek branch, Pennsylvania Railroad.
19. Mine No. 2, Delmont Gas Coal Company, ¾ mile northwest of Delmont.
20. Country bank, V. W. Keenan farm, Thorn Run, 2½ miles northeast of Export, Franklin township.
21. Country bank, William Steel Heirs, 3 miles north of Export, Franklin township.
22. Country bank, W. Cline, 2 miles northeast of Export, Franklin township.
23. Outcrop, ½ mile east of Export, Franklin township.
24. Export No. 2 mine, Westmoreland Coal Company, Export, Franklin township.
25. Export No. 1 mine, Westmoreland Coal Company, Export, Franklin township.
26. Same as last, different part of mine.
27. Elizabeth mine, W. B. Skelly Coal Company, 2,000 feet northwest of Export Station, Export, Franklin township.
28. Kathryn mine, Camberdif Coal Company, 1¼ miles northeast of Manordale cross-roads, Franklin townships.
29. Mine No. 2, Irwin Gas Coal Company, 1½ miles northeast of Pleasant Valley, Penn township.
30. Edwards No. 2 mine, Edwards Coal Company, ½ mile northeast of Pleasant Valley, Penn township.
31. Hilda mine, Hilda Coal Company, 1 mile southwest of Pleasant Valley, Penn township. Section at entrance to mine.
32. Same as last. Section inside mine.
33. Pollins No. 2 mine, A. H. Pollins, ¾ mile southwest of Pleasant Valley, Penn township.
34. John Carr and Sons mine, 1 mile north of Paintertown, Penn township.
35. Byerly mine, Byerly Gas Coal Company, 1¼ miles west of Larimer, North Huntingdon township.
36. Country bank, Mike Plank, ½ mile south of Larimer.
37. Colinear mine, Irwin Valley Gas Coal Company, ¾ mile west of Larimer, North Huntingdon township.
38. Hawk mine, John S. Carr, 1 mile west of Paintertown, Penn township.
39. Schade mine, Irwin Valley Gas Coal Company, ½ mile northwest of North Irwin, North Huntingdon township.
40. Bald Eagle mine, Bald Eagle Coal Company, west edge of North Irwin, North Huntingdon township.
41. South-Side mine, Westmoreland Coal Company, northwest edge of Irwin, North Huntingdon township. Section at entrance to mine.
42. Same as last. Section inside mine.

Fig. 14. Sections of Pittsburgh coal in the Greensburg quadrangle.

43. Adams mine, Westmoreland Coal Company, southwest edge of Irwin, North Huntingdon township.
44. Same as last. Different part of mine.
45. Criterion mine, Westmoreland Coal Company, Rillton, Sewickley township.
46. Same as last. Different part of mine.
47. Ocean No. 1 mine, Ocean Coal Company, Herminie, Sewickley township.
48. Keystone shaft and Sewickley slope, Keystone Coal & Coke Company, ½ mile east of Herminie.
49. Virgie No. 2 mine, Byrne Coal & Coke Company, ¼ mile south of Madison Station, Hempfield Branch of Pennsylvania Railroad.
50. Same as last. Section measured at entrance.
51. Hillside mine, J. S. Kendall, Arona, Hempfield township.
52. Country bank, 1½ miles south of Arona, Hempfield township.
53. Country bank, 1 mile south of Arona, Hempfield township.
54. Country bank, L Snyder farm, ¾ mile south of Arona, Hempfield township.
55. Country bank, W. H. Bussard farm, ½ mile north of B. M. 1020 near Arona, Hempfield township.
56. Country bank, 1 mile north of Arona, Hempfield township.
57. Arona mine, Keystone Coal and Coke Company, ¼ mile east of Darragh, Hempfield township.
58. Ocean No. 2 mine, Ocean Coal Company, 1 mile south of Edna No. 2 mine, Hempfield township.
59. Country bank, John D. Earhardt, 1¼ miles southeast of Edna No. 2 mine, Hempfield township.
60. Earhardt mine, Fairview Coal Company, 2 miles north of Arona.
61. Little Gem mine, Edward Tomajko, ¾ mile south-southwest of Edna No. 1 mine, Hempfield township.
62. Edna No. 1 mine, Hillman Coal & Coke Company, Hempfield township.
63. Country bank, Feree farm, ½ mile northeast of Adamsburg, Hempfield township.
64. Country bank, Harmon farm, ½ mile south of Penn Station, Penn township.
65. Penn mine, Westmoreland Coal Company, located in bend of Brush Creek ½ mile west of Penn Station, Penn township. Section near entrance.
66. Same as last. Section inside mine.
67. Country bank, 1 mile north of Penn Station, Penn township.
68. Biddle mine, Westmoreland Coal Company, Biddle, North Huntingdon township.
69. Penn Manor No. 1 mine, Union Coal & Coke Company, Manor, Penn township.
70. McCullough mine, Westmoreland Coal Company, 1 mile north-northeast of Harrison City, Penn township.
71. Penn Manor No. 5 mine, Union Coal & Coke Company, 1 mile northeast of Harrison City, Penn township.
72. Denmark mine, Westmoreland Coal Company, Claridge, Penn township.
73. Claridge mine, Keystone Coal & Coke Company, Claridge, Penn township.
74. Kew mine, Claridge Coal Company, ½ mile south-southwest of Boquet, Penn township.
75. Country bank, ¾ mile southwest of Boquet, Penn township.
76. Country bank, Mrs. R. Coulter farm, 2 miles north-northwest of the railroad station at Greensburg.
77. Victor mine, Jeannette Ice Company, on Delmont road, 1¼ miles north of railroad station at Greensburg.
78. Highland mine, Keystone Coal & Coke Company, 1¼ miles northeast of railroad station at Greensburg.
79. Hawksworth mine, Greensburg Coal & Coke Company, on main line of Pennsylvania Railroad, 1 mile west of the Greensburg station.
80. Greensburg No. 3 mine, Keystone Coal & Coke Company, on main line of Pennsylvania Railroad, 1½ miles west of the Greensburg station.
81. Country bank, Armstrong Brothers, ½ mile east of Radebaugh, Hempfield township.
82. Orchard Hill mine, George B. Taylor, 1 mile west-northwest of Carbon, Hempfield township.
83. Country bank, 50 feet south of Lincoln Highway and about ½ mile southeast of Radebaugh, Hempfield township.
84. Country bank, A. Halberg, ¾ mile northwest of Swede Hill, Hempfield township.
85. Country bank, J. L. Diemer, ½ mile south of Swede Hill, Hempfield township.
86. Country bank, near County Home, southwest of Huff, Hempfield township.
87. Country bank, William H. Maxwell farm, ¾ mile west-southwest of Fosterville, Hempfield township.
88. Country bank, Daniels and Goldberg, ½ mile west of Fosterville, Hempfield township.
89. Country bank, Jacob Funk, on Greensburg-Unity road, ½ mile southeast of Jacks Run and ½ mile northwest of BM 1055.
90. Greensburg No. 1 mine, Keystone Coal & Coke Company, ¼ mile north of Huff, Hempfield township.

91. Kilgore mine, Valley Coal Company, 100 yards east of Pennsylvania Railroad tracks at south edge of Greensburg.
92. Country bank, James Walls, near cemetery 1 mile east of Greensburg and $\frac{1}{2}$ mile south of Lincoln Highway.

The sections showing the roof coal give some idea of the variations in the latter, although probably not an adequate one. The following sections of the roof division afford additional illustration of this characteristic:

Sections of Pittsburgh roof coal.

Near Arona	Ft.	in.	1/2 mile east of Export	Ft.	in.	Hilda mine, near Pleasant Valley	Ft.	in.
Shale			Shale, black			Shale		
Coal		2	Coal, bony	1		Coal		3
Shale		11	Clay-shale	1		Shale		7
Coal		9	Coal		4	Coal, shaly		8
Shale		10	Shale, black		3	Clay		8
Coal	1	11	Coal		10	Coal		4
Draw slate			Clay-shale		8	Shale		2
			Coal	1		Coal and partings	1	1
			Draw slate			Shale, black		2
						Coal	1	
						Draw slate		

Although the roof coal is now considered worthless, it is believed that some day at least a part of it, the so called "rooster" coal, will be mined, particularly where it can be taken out easily with the main bed. The roof coal is not mined now because it forms a good roof and it is more economical to leave it in place. Were the "rooster" coal taken out, the shale and coal above would quickly come down unless many additional mine props were made.

The Pittsburgh coal is less troubled by "faults" and "horsebacks" probably than any of the other mineable coals in the Greensburg quadrangle. Occasional clay veins and sandstone "horsebacks" have been encountered, however, and for short distances on either side of such veins or horsebacks the coal is "curled" and rendered much less valuable. Clay veins are worse in this respect as the coal is affected also by the infiltration of fine clay along minute cleavage cracks, etc.

Since faulting is practically unknown in the quadrangle, no trouble in mining is experienced from this source. Local rolls sometimes occur, as that shown on the structure sheet in the outskirts of Greensburg, which are exasperating to the miner and which increase the cost of mining.

The coal is uniform not only in physical characteristics but in its chemical character as well. Over wide areas the proximate and ultimate analyses of the coal show little variation. The following analyses of samples taken at the points indicated in Fig. 15 show this constancy in chemical character.

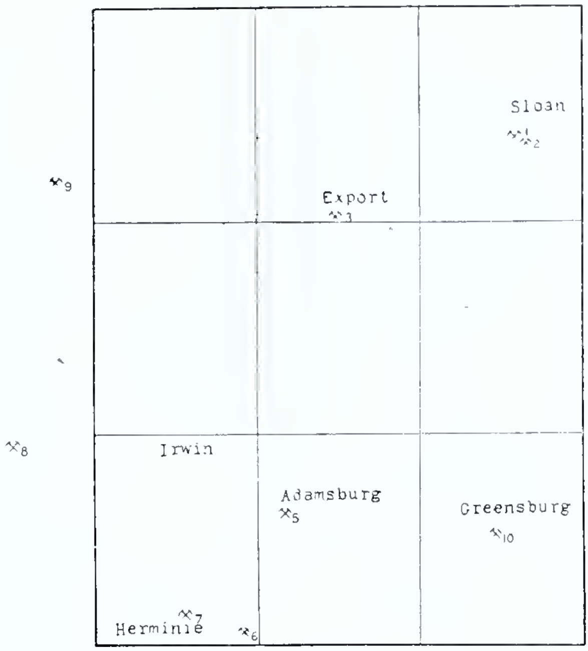


Fig. 15. Localities where samples of Pittsburgh coal were taken for analysis.

Analyses of Pittsburgh coal.

(H. M. Cooper, U. S. Bureau of Mines, analyst)

Locality	Proximate, as received		Ultimate, as received		Calorific value	
					Calories	B. t. u.
1. Frank Rugh mine, ½ mile west of Slickville (1 mile north of Sloan) Sample No. Composite 83662	Moisture Vol. matter Fixed carbon Ash	3.38 33.00 55.25 8.37 100.00	Hydrogen Carbon Nitrogen Oxygen Sulphur Ash	5.24 74.87 1.54 8.57 1.41 8.37 100.00	7,441	13,3[illegible]4
2. Edwards mine, ½ mile west of Slickville Sample No. Composite 83659	Moisture Vol. matter Fixed carbon Ash	3.36 33.15 55.47 8.02 100.00	Hydrogen Carbon Nitrogen Oxygen Sulphur Ash	5.29 75.14 1.58 8.75 1.22 8.02 100.00	7,456	13,421
3. Elizabeth mine, Export Sample No. Composite 84761	Moisture Vol. matter Fixed carbon Ash	3.9 33.6 57.0 5.5 100.0	Hydrogen Carbon Nitrogen Oxygen Sulphur Ash	5.4 76.2 1.6 10.1 1.2 5.5 100.0	7,585	13,6[illegible]0
4. Jamison No. 2 mine, 4 miles northeast of Greensburg Sample No. 1942	Moisture Vol. matter Fixed carbon Ash Sulphur	2.73 30.34 57.80 9.13 100.00 1.33			7,563	13,613

Locality	Proximate, as received		Ultimate, as received		Calorific value	
					Calories	B. t. u.
5. Edna No. 1 mine, ¾ mile south of Adamsburg Car sample	Moisture	4.39			7,231	13,016
	Vol. matter	34.53 (Dry coal)				
	Fixed carbon	55.68 (Dry coal)				
	Ash	9.79 (Dry coal)				
		100.00				
	Sulphur	1.84				
6. Arona mine, Keystone Coal and Coke Co., Madison Sta., Hempfield township. Sample No. 16270	Moisture	3.26	Hydrogen	4.96	7,231	13,016
	Vol. matter	30.68	Carbon	72.97		
	Fixed carbon	55.01	Nitrogen	1.41		
	Ash	11.05	Oxygen	8.12		
		100.00	Sulphur	1.49		
			Ash	11.05		
				100.00		
7. Keystone mine, Keystone Coal and Coke Co., ½ mile east of Herminie. Sample No. 4352	Moisture	2.01			7,862	14,152
	Vol. matter	33.56				
	Fixed carbon	58.11				
	Ash	6.32				
		100.00				
	Sulphur	1.39				
8. Mine No. 2, Union Valley Coal Co., 5 miles east of McKeesport Sample No. Composite 82398	Moisture	3.23	Hydrogen	5.32	7,496	13,493
	Vol. matter	32.77	Carbon	75.11		
	Fixed carbon	56.50	Nitrogen	1.49		
	Ash	7.50	Oxygen	9.18		
		100.00	Sulphur	1.40		
			Ash	7.50		
				100.00		
9. Herold & Bowers mine, Monroeville, Patton twp., Allegheny Co. Sample No. Composite 82223	Moisture	2.93	Hydrogen	5.37	7,328	13,515
	Vol. matter	34.93	Carbon	75.39		
	Fixed carbon	54.82	Nitrogen	1.44		
	Ash	7.32	Oxygen	9.30		
		100.00	Sulphur	1.18		
			Ash	7.32		
				100.00		
10. Greensburg No. 1 mine, Keystone Coal and Coke Co., 1 mile south of Greensburg Sample No. 4498 Car sample	Moisture	3.98			7,395	13,311
	Vol. matter	28.13				
	Fixed carbon	57.73				
	Ash	10.16				
		100.00				
	Sulphur	1.00				

It is evident from the analyses given that coal from the Pittsburgh bed is low enough in sulphur and ash to make it desirable on that account alone. These, and its other good qualities have earned for it an enviable reputation.

Much of the coal from the Irwin basin is used for industrial purposes such as by-product coke manufacture, in foundries and steel mills, for raising steam in power plants, etc. This coal is noted for its quality as a gas-coal and is used, chiefly in New England, for this purpose in municipal gas works. Coal from both the Irwin and Greensburg basins is used by railroads for fuel, the Irwin basin coal being largely used for that purpose.

Tests[9] have been made of several samples of Pittsburgh coal from this area to determine its steaming qualities. Although the water

[9]Holmes, J. A., Preliminary report on the operations of the fuel testing plant of the United States Geological Survey at St. Louis, Mo., 1905: U. S. Geol. Survey Bull. 290, pp. 166-168, 1906.
Holmes, J. A., Report of the United States fuel-testing plant at St. Louis, Mo., January 1, 1906, to June 30, 1907: U. S. Geol. Survey Bull. 332, pp. 213-214 and 221, 1908.

evaporated per pound of fuel is less than that of some of the West Virginia coals and some of the Pennsylvania bituminous coals mined farther east, the amount is high for strictly bituminous coal.

As a coking coal[10] the Pittsburgh has no superior in the state of Pennslvania. For many years the Connellsville region produced a coke which was considered a standard for the world, and although it has rivals now, it still rules supreme in its own territory—the Pittsburgh district.

The Pittsburgh coal has been mined more or less vigorously ever since the inception of coal mining in the Greensburg district. One of the large companies now operating in this quadrangle has been producing coal since 1854. The maximum production in the quadrangle was during the World War and the two years following, when about 7,000,000 tons was produced annually.

Knowing the areal extent of the coal and having accurate measured sections at many points in the quadrangle, it has been possible to calculate very closely the total original tonnage before mining operations began. The figures for tonnage mined and reserve tonnage are also quite reliable.

Pittsburgh coal tonnages—Greensburg quadrangle

	Short tons
Total original deposit	592,560,000
Mined	346,383,000
Reserve	246,177,000
Recoverable coal	188,300,000

Duquesne coal. The Duquesne coal is of such small extent where thick enough to be mined as to hardly warrant mentioning as a mineral resource. The coal is of good quality, however, and occurs in possibly one-third of the total area of the quadrangle. The only locality in which it has been worked is about half-way between Delmont and Five Points, where it attains a maximum thickness of 30 inches. This is purely a local development, the coal thinning in all directions. The total production of coal from this source will never amount to more than a few thousand tons.

Harlem coal. The Harlem coal, is also economically unimportant. Nowhere in the quadrangle does it attain a thickness of over 2 feet 6 inches, and only locally is it as much as two feet. It is missing in much of the quadrangle, particularly in the west, and is persistent only in the southeast quarter. The coal was seen only at its outcrop, the few entries driven into it having been abandoned years ago. As a consequence little is known of its physical and chemical characteristics.

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[10]Holmes, J. A., Op. cit., Bull. 332, p. 215, 1908.

The Harlem coal is always found close beneath the Ames limestone and usually has a shale roof and floor. In places it directly underlies the Ames.

Figure 16 shows sections of the Harlem coal at those points where it was found to be thickest.

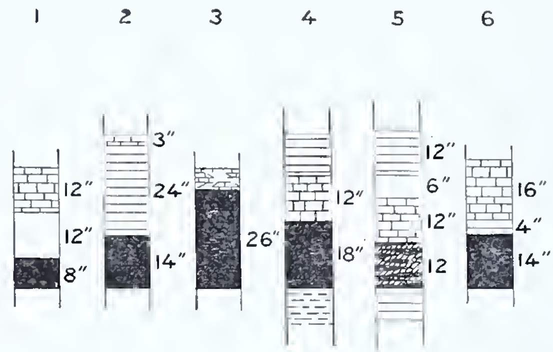


Fig. 16. Sections of Harlem coal.

1. Outcrop, 1 mile east-southeast of Fosterville, Hempfield township.
2. Outcrop, 1 mile south-southwest of Fosterville, Hempfield township.
3. Prospect entry, ½ mile west of southeast corner of quadrangle.
4. Outcrop, ¾ mile southwest of BM 1012 at Eisaman, Hempfield township.
5. Outcrop, 1½ miles south-southwest of Five Points, Salem township.
6. Outcrop, 1 mile east-southeast of Delmont, Salem township.

Upper and Lower Bakerstown coals. Although one or the other of these coals is found in many parts of the quadrangle, the localities in which either is thick enough to be mined are few and of very restricted area. Both the Upper and Lower Bakerstown are habitually broken by shale partings of variable thickness and occurrence. The character of the coal changes so rapidly within short distances that measured sections taken only a quarter of a mile apart usually show little similarity. The only locality in which the Upper Bakerstown will ever be mined is a small area two or three miles south of Greensburg where it attains a maximum thickness of 52 inches. Several prospect entries have been driven in the coal there but no appreciable tonnage has ever been mined because of the poor quality of the coal and its extreme variability. In no other part of the quadrangle does the coal attain a thickness of over thirty inches.

The Lower Bakerstown is unimportant except in one very small area of about two hundred acres, a mile and a half to two miles south of Grapeville. There it is being mined on a small scale at several country banks, the total production in a year not exceeding ten thousand tons. Probably one-half of the total amount of coal has already been mined and the recovery of the remainder will be increasingly difficult. In this small area the coal attains a surprising thickness, one section measuring 88 inches. The coal

usually has a shale roof and floor although a thin clay frequently occurs immediately above or below the coal. Where of mineable thickness the coal is of medium hardness and brightness and has cubical fracture. "Sulphur balls" are common and the percentage of ash is high.

Analyses of Bakerstown coal.

(H. M. Cooper, U. S. Bureau of Mines, analyst.)

Locality	Sample No.	Proximate, as received		Calorific value	
				Calories	B. t. u.
Lawson country bank, 1½ miles east of Huff, Hempfield township Upper Bakerstown	81072	Moisture	1.82	6,516	11,728
		Vol. matter	30.58		
		Fixed carbon	47.09		
		Ash	20.51		
			100.00		
		Sulphur	4.26		
J. Miller country bank, 4½ miles west-southwest of Greensburg Lower Bakerstown	81149	Moisture	2.15	6,460	11,627
		Vol. matter	32.71		
		Fixed carbon	44.92		
		Ash	20.22		
			100.00		
		Sulphur	2.67		

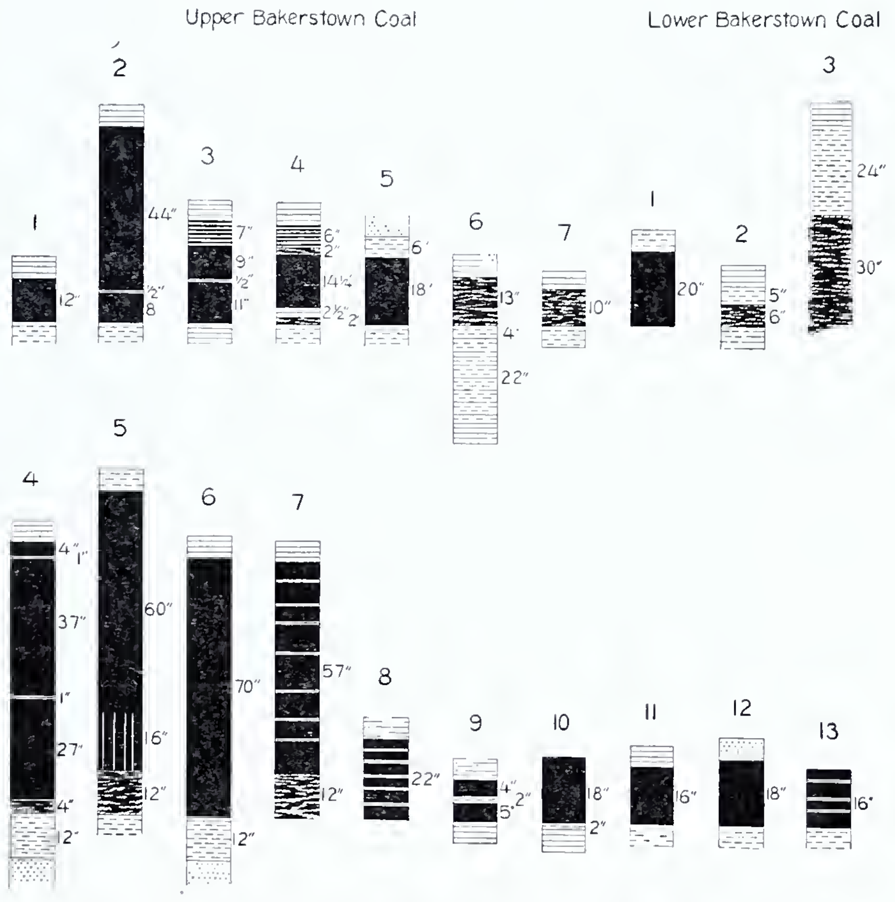


Fig. 17. Sections of Upper and Lower Bakerstown coals.

Following is a list of the places where the sections in Figure 17 were measured.

UPPER BAKERSTOWN COAL.

1. Outcrop, ¼ mile west of BM 1157 near Huff, Hempfield township.
2. Country bank, abandoned, W. K. and H. B. Jamison, 2 miles east of Fosterville, Hempfield township.
3. Country bank, Lawson, 1 mile east of Huff, Hempfield township.
4. Prospect entry, ½ mile northwest of Pennine, Hempfield township.
5. Outcrop, ¾ mile west of Five Points, Salem township.
6. Outcrop, 1½ miles east of Boquet, Penn township.
7. Outcrop, ½ mile northeast of BM 1069 near Blackburn, Penn township.

LOWER BAKERSTOWN COAL.

1. Country bank, abandoned, Joseph Gaskey farm, 1¼ miles southeast of Fosterville, Hempfield township.
2. Prospect entry, ¾ mile southeast of BM 1012 at Eisaman, Hempfield township.
3. Prospect entry, 1 mile southwest of BM 1112 near Pennine, Hempfield township.
4. Country bank, J. F. Baughman, ½ mile west of Pennine, Hempfield township.
5. Country bank, James Miller farm, ¾ mile west of Pennine, Hempfield township.
6. Same as last. Different section.
7. Country bank, Carl Orczeck farm, 1¾ miles south of Grapeville, Hempfield township.
8. Outcrop, ¾ mile west-northwest of BM 1080 near Jeannette.
9. Outcrop, ¼ mile northeast of railroad station at Jeannette.
10. Outcrop, ½ mile northeast of BM 1036 near Jeannette.
11. Outcrop, ½ mile east of BM 1391 and 3 miles south of Delmont, Salem township.
12. Outcrop, 1½ miles west of Wiester, Washington township.
13. Outcrop, ¼ mile northwest of BM 1017, Pucketa Creek, Washington township.

Brush Creek coal. Although quite persistent over much of the quadrangle, the Brush Creek coal is usually thin and has been worked in only two localities: namely, near Eisaman, along the Grapeville anticline, and in the extreme northern part of the quadrangle along Poke Run. It has been worked to a greater extent in the latter area, although no mining has been done in recent years. The maximum observed thickness along Poke Run was three feet; the usual thickness about 18 inches. The farmers declare that it is over 3 feet thick in some of the old country banks. The coal occurs anywhere from immediately beneath the Brush Creek limestone to 15 or 20 feet beneath it. Where exposed the coal is weathered and shaly. All of the old country banks have fallen in, making the fresh coal inaccessible now.

Along the Grapeville anticline the maximum observed thickness of the Brush Creek coal was two feet. The writer believes the coal is not thick enough in this locality to warrant working for many years to come. However, the coal is apparently of better quality here than in the north.

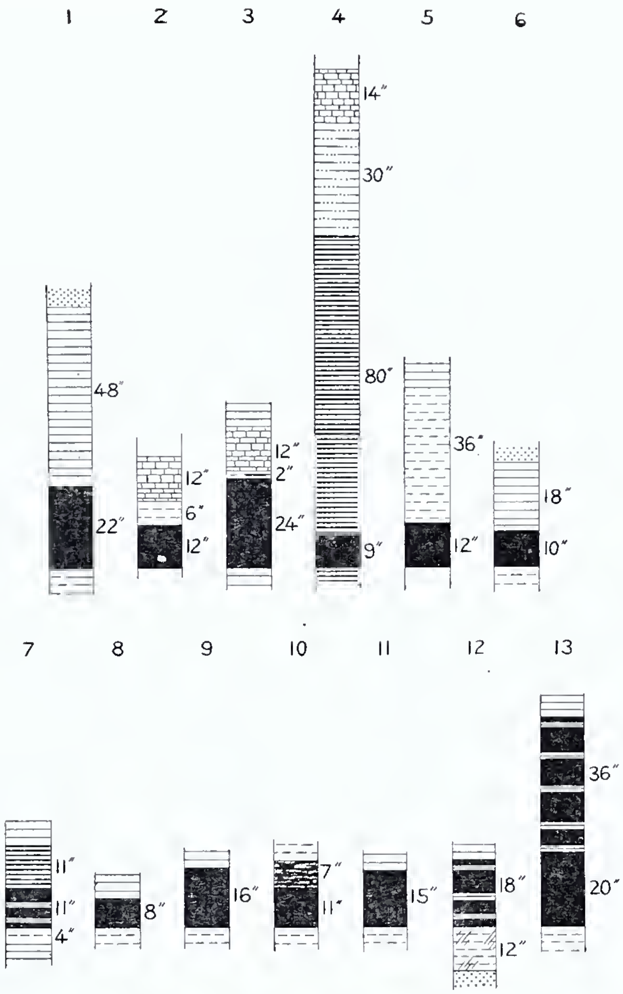


Fig. 18. Sections of Brush Creek coal.

The sections in Figure 18 were measured at the following places.

1. Outcrop, Division Street, Jeannette.
2. Prospect entry, Grant Wentzel farm, ½ mile southeast of BM 1012 at Eisaman, Hempfield township.
3. Prospect entry, Gustav Erickson farm, ½ mile east of BM 1012 at Eisaman, Hempfield township.
4. Prospect entry, 1 mile southeast of Edna No. 1 mine, Hempfield township.
5. Outcrop, 1½ miles east-southeast of Fosterville, Hempfield township.
6. Outcrop, railroad cut 100 yards east of Jeannette station.
7. Outcrop, 2 miles northwest of Pleasant Valley, Penn township.
8. Outcrop, ¼ mile west of BM 903 at Murrysville, Franklin township.
9. Outcrop, 1⅓ miles southwest of Bulltown Schoolhouse, Franklin township.
10. Outcrop, 1¼ miles east-southeast of BM 1017 in valley of Pucketa Creek, Washington-Franklin township line.
11. Outcrop, ⅜ mile north-northwest of Wiester, Washington township.
12. Outcrop, 1¼ miles north-northwest of Wiester, Washington township.
13. Outcrop, 1¼ miles northeast of Wiester, Washington township.

Mahoning coal. The Mahoning coal bed, like the Bakerstown, is of mineable thickness in only a small part of the quadrangle. Drill-holes and outcrops show it to be thin in the western, central, and southeastern parts of the quadrangle. It has been worked at sev-

eral points along the Grapeville anticline, where it attains its maximum thickness; also along the upper part of Pucketa Creek near the axis of the Murrysville anticline. It is reported as five feet thick in some of the old openings but no opportunity was afforded to confirm this statement. Northeast of Export it has been cut by drill-holes and is apparently of workable thickness. The coal is usually low in sulphur and ash, has cubical fracture and bright lustre, and were it of greater thickness and extent, would doubtless be valued highly.

Usually the coal is banded, containing jet-black, lustrous, and softer, less brilliant streaks. One and sometimes more clay binders may be present and "sulphur balls" are not infrequent impurities.

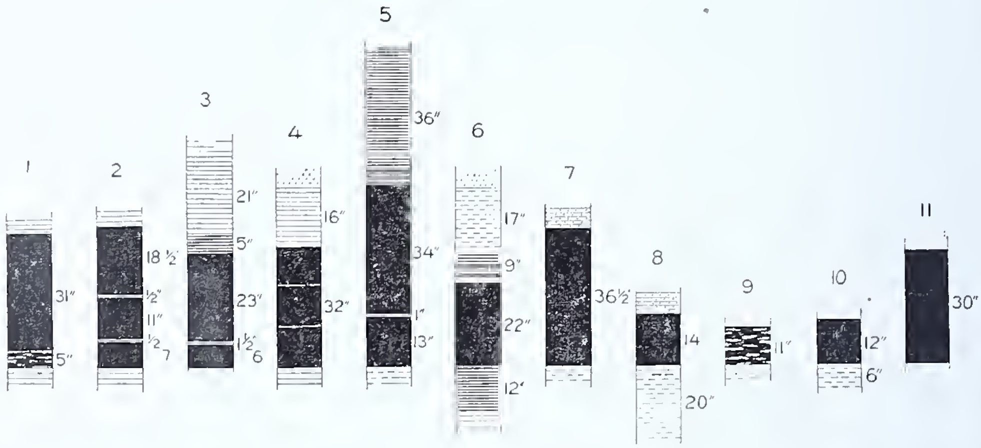


Fig. 19. Sections of Mahoning coal.

The sections in Figure 19 were measured at the following places.

1. Country bank, Paul Delvitto, ¼ mile east of BM 1012 at Eisaman, Hempfield township. Section at entrance to mine.
2. Same as last. Section inside mine.
3. Country bank, abandoned, J. M. Henry, 1¼ miles south of Grapeville, Hempfield township.
4. Prospect entry, James Martin, ¼ mile northwest of BM 1036 near Jeannette.
5. Country bank, Smail Brothers, 1 mile northeast of BM 1036 near Jeannette.
6. Country bank, H. Christman, 2 miles northeast of Jeannette railroad station.
7. Outcrop, 100 yards south of BM 1181, Salem and Penn townships. About 2¼ miles southeast of Boquet, Penn township.
8. Outcrop, 100 yards north of section.
9. Outcrop, ¼ mile southeast of BM 897 near Murrysville, Franklin township.
10. Outcrop, 1 mile east of Bulltown Schoolhouse, Franklin township.
11. Country bank, abandoned, 1½ miles northwest of Wiester, Washington township.

Analyses of Mahoning coal.

(H. M. Cooper, U. S. Bureau of Mines, analyst.)

Locality	Proximate as received		Ultimate, as received		Calorific value	
					Calories	B. t. u.
Delvitto mine, ½ mile east of Eisaman	Moisture	2.00	Hydrogen	5.3	7,582	13,670
Sample No. 84737	Vol. matter	35.0	Carbon	75.6		
	Fixed carbon	54.39	Nitrogen	1.5		
	Ash	8.2	Oxygen	6.6		
			Sulphur	2.8		
		100.00	Ash	8.2		
				100.0		
Small Bros. mine, 1¾ miles north-east of Jeannette	Moisture	3.66			7,445	13,400
Sample No. 81148	Vol. matter	33.89				
	Fixed carbon	54.39				
	Ash	8.06				
		100.00				
	Sulphur	2.20				
H. Christman country bank 2 miles northeast of Jeannette.	Moisture	3.79			6,437	11,586
Sample No. 81146	Vol. matter	29.69				
	Fixed carbon	47.97				
	Ash	18.55				
		100.00				
	Sulphur	7.02				

From the analyses it is seen that the Mahoning coal sometimes compares very favorably with the Pittsburgh coal and should obtain a better price than Waynesburg or Bakerstown coal. At present it is worked only on a very small scale at a few country banks. This is largely due to its limited outcrop and areal extent, and possibly also to the fact that its excellent qualities are not generally known. Knowledge of its good qualities may cause it to be worked more extensively in the future.

Upper Freeport coal. The Upper Freeport outcrops in only two localities in the whole quadrangle (See Plate V, in pocket). A very short outcrop of the coal is exposed at Oakford Park, east of Jeannette, and a slightly longer outcrop in Haymakers Run, a mile and a half northeast of Murrysville. In the latter area the coal is soft and shaly and in general rather worthless. At Oakford Park the coal is being mined on a small scale and an analysis of a sample taken at the Oakford Park mine shows the coal to be of excellent quality.

The area underlain by the Upper Freeport coal is shown in Fig. 5, p. 71. In one large area the coal is absent. It is evident from the data at hand that when the carbonaceous material (which later was compacted into the Upper Freeport coal) was being deposited, there was a roughly circular island in the central part of the quadrangle. Either that or else that particular area was raised above the level of the surrounding territory for a short period and the coal was eroded, the circular island then subsiding below the surface of the inland sea. In spite of the fact that in this large

central area there is no Upper Freeport coal, the tonnage available in the quadrangle is large.

The coal at Oakford Park is coarsely banded, breaks with a cubical fracture, has a dull to medium lustre, is hard at the top of the bed and soft below, and contains a few thin binders and many "sulphur balls." It is underlain by clay and overlain by shale and thin sandstone.

Frequently the Upper Freeport has a double binder near the base. In the "Thick Freeport" area northwest of Murrysville, this is almost invariably the case. Elsewhere it is not such a persistent feature.

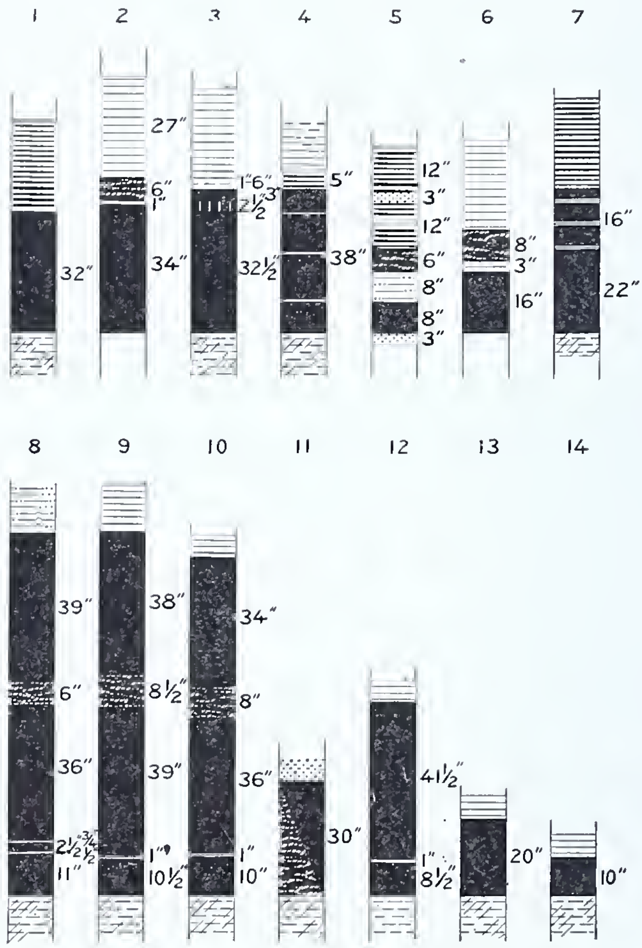


Fig. 20. Sections of Upper Freeport coal.

The sections in Figure 20 were measured at the following places.

1. Outcrop in stream bank, Oakford Park, 1¼ miles east of railroad station at Jeannette.
2. Oakford Park mine, Ruffner Brothers, 1 mile east of railroad station at Jeannette. Section near entrance.
3. Same as last. Section inside mine.
4. Outcrop, 1½ miles southeast of Bulltown Schoolhouse, Franklin township.
5. Outcrop, 1¼ miles northeast of BM 903 at Murrysville, Franklin township.
6. Country bank, 1½ miles northeast of BM 903 at Murrysville, Franklin township.

7. Outcrop, 2 miles northeast of BM 903 at Murrysville, Franklin township.
8. Diamond drill-hole, 2 miles northwest of Sardis, Franklin township.
9. Diamond drill-hole, $\frac{1}{5}$ mile southeast of New Texas, Plum township.
10. Diamond drill-hole, $\frac{3}{4}$ mile west of Sardis, Franklin township.
11. Diamond drill-hole, $1\frac{1}{4}$ miles east of Sardis, Franklin township.
12. Diamond drill-hole, $\frac{1}{2}$ mile southeast of Plum Creek Church, Plum township.
13. Diamond drill-hole, $1\frac{1}{4}$ miles south of Plum Creek Church, Plum township.
14. Diamond drill-hole, $1\frac{3}{4}$ miles southeast of Plum Creek Church, Plum township.

Drill-holes show that the coal is of workable thickness in the northeast corner and in a strip along the southern border of the quadrangle.

Analyses of the Upper Freeport show that the coal is moderately low in sulphur and ash and is suitable for gas-making, as a steam coal, and in general for most uses to which the Pittsburgh coal is put.

Analyses of Upper Freeport coal.

(H. M. Cooper, U. S. Bureau of Mines, analyst)

Locality	Proximate, as received		Ultimate, as received		Calorific value	
					Calories	B. t. u.
Westmoreland Brick Co. mine, 5 miles south of Middletown, Hempfield Twp.	Moisture	2.7	Hydrogen	5.3	7,628	13,730
Sample No. Composite 85340	Vol. matter	34.8	Carbon	75.2		
	Fixed carbon	54.6	Nitrogen	1.3		
	Ash	7.9	Oxygen	6.7		
		100.0	Sulphur	3.6		
			Ash	7.9		
				100.0		
John Sreanko country bank, 7 miles east of Greensburg	Moisture	2.0	Hydrogen	5.2	7,794	14,310
Sample No. Composite 85337	Vol. matter	31.8	Carbon	78.0		
	Fixed carbon	59.2	Nitrogen	1.4		
	Ash	7.0	Oxygen	6.5		
		100.0	Sulphur	1.9		
			Ash	7.0		
				100.0		
Apollo No. 1 mine, $2\frac{1}{4}$ miles north of north-east corner of quadrangle	Moisture	2.5	Hydrogen	5.2	7,394	13,310
Sample No. Composite 85082	Vol. matter	34.6	Carbon	73.5		
	Fixed carbon	53.5	Nitrogen	1.3		
	Ash	9.4	Oxygen	7.2		
		100.0	Sulphur	3.4		
			Ash	9.4		
				100.0		
L. Sandell (now Ruffner Bros.) country bank, 1 mile east of Jeannette	Moisture	2.00			7,539	13,570
	Vol. matter	33.60				
	Fixed carbon	55.14				
	Ash	9.26				
		100.00				
	Sulphur	2.86				
No. 1 mine, New Fields By-Product Coal Co., 3 miles west of northwest boundary of quadrangle	Moisture	1.4			7,556	13,600
Upper bench	Vol. matter	35.1				
Sample No. 83118	Fixed carbon	54.1				
	Ash	9.4				
		100.0				
	Sulphur	2.2				
Same	Moisture	2.0			7,761	13,970
Lower bench	Vol. matter	35.1				
Sample No. 83119	Fixed carbon	56.9				
	Ash	6.1				
		100.1				
	Sulphur	0.9				

Production in the past has been small, but it is believed that with the approaching exhaustion of the Pittsburgh coal, more and more attention will be paid to the Upper Freeport coal.

Production and reserves of Upper Freeport coal.

	Short tons
Total original deposit	343,980,000
Mined	980,000
Reserve	343,000,000
Recoverable coal	233,000,000

Kittanning coals. Each of the Kittanning coals underlies at least a part of the Greensburg quadrangle (see Fig. 6, p. 71), although just how much it is not possible to say now. The Middle Kittanning coal is the thickest and probably the most persistent of the group. Although sometimes reported in churn drill-hole records as being ten feet or more thick, it is doubted if any of the group is over four feet, at the most five feet, in more than a very restricted area.

Since none of the Kittanning or lower coal beds outcrop it is impossible to give any detailed description or analyses of them. Certainly their value is theoretical now as none of them will be mined until long after the Pittsburgh coal has been exhausted and the price of bituminous coal has advanced far above its present level.

Estimated tonnages of Kittanning coals.

Coal bed	Total original tonnage	Tonnage mined	Recoverable coal
Upper Kittanning	100,000,000	None	30,000,000
Middle Kittanning	486,000,000	"	206,500,000
Lower Kittanning	240,000,000	"	101,800,000

COMMERCIAL COAL MINES.

In 1923 the Pennsylvania Department of Mines received production reports from 53 mines in the Greensburg quadrangle. Of these, 28 mines, produced 6,817,237 tons, each of them producing over 100,000 tons during the year. The remaining 25 mines that made reports, produced 725,681 tons or an average of about 29,-300 tons per mine. In addition to the larger mines, possibly 50 small mines or "country banks" operated during at least a part of the year. Their estimated total production is placed at 175,000 tons. Hence the total production for the quadrangle in 1923 was approximately 7,718,000 tons. The following list contains only the names of those mines which reported their production in 1923:

Commercial coal mines in the Greensburg quadrangle.

	Name of mine	Location (nearest town or village)	Company	Bed	*Tonnage (1923)
1.	Louise No. 1	Slickville (near Sloan)	Howard Gas Coal Co.	Pittsburgh	157,228
2.	Irwin Gas No. 4	"	Irwin Gas Coal Co.	"	109,089
3.	Irwin Gas No. 3	"	" " " "	"	83,394
4.	Slick No. 2	"	Cambria Steel Co.	"	
5.	Slick No. 3	"	" " "	"	781,652
6.	Slick No. 1	"	" " "	"	
7.	Irwin Gas No. 5 (was Keibler)	"	Irwin Gas Coal Co.	"	26,342
8.	Edwards No. 3	"	Edwards Coal Co.	"	30,639
9.	Delmont Gas No. 4	Delmont	Delmont Gas Coal Co.	"	68,240
10.	Delmont Gas, No. 2	"	" " " "	"	71,360
11.	Irwin Gas No. 6 (was Lauffer)	"	Irwin Gas Coal Co.	"	89,269
12.	Delmont No. 3	"	Pittsburgh Gas Coal Co.	"	
13.	Delmont No. 2	"	" " " "	"	688,253
14.	Delmont No. 1	"	" " " "	"	
15.	Export No. 1	Export	Westmoreland Coal Co.	"	289,555
16.	Export No. 2	"	" " "	"	240,015
17.	Elizabeth	"	W. B. Skelly Co.	"	59,808
18.	Star	"	Trafford Coal Co.	"	6,000
19.	Irwin Gas No. 2	Pleasant Valley	Irwin Gas Co.		198,696
20.	Lyons Run	" "	Pittsburgh Coal Co.	"	23,881
21.	Carr	Paintertown	Carr, John & Son	"	3,011
22.	Kew	Boquet	Claridge Coal Co.	"	63,893
23.	Denmark	Claridge	Westmoreland Coal Co.	"	390,450
24.	Claridge	"	Keystone Coal & Coke Co.	"	3,133
25.	McCullough	"	Westmoreland Coal Co.	"	360,566
26.	Penn	Penn	" " "	"	119,934
27.	Colinear	Larimer	Irwin Valley Gas Coal Co.	"	5,793
28.	Bald Eagle	Irwin	Bald Eagle Coal Co.	"	3,699
29.	Southside	"	Westmoreland Coal Co.	"	16,538
30.	Criterion	Rillton	" " "	"	277,372
31.	Adams	Irwin	" " "	"	213,312
32.	Biddle	Biddle	" " "	"	359,436

*Production figures from Pennsylvania Department of Mines.

Commercial coal mines in the Greensburg quadrangle.—Continued.

	Name of mine	Location (nearest town or village)	Company	Bed	*Tonnage (1923
33.	Ocean No. 1	Herminie	Ocean Coal Co.	Pittsburgh	429,862
34.	Ocean No. 2	"	" " "	"	280,726
35.	Edna No. 2	Edna No. 2	Hillman Coal & Coke Co.	"	210,347
36.	Herminie	Herminie	Fairhaven Coal Co.	Waynesburg	14,469
37.	Keystone Shaft	"	Keystone Coal & Coke Co.	Pittsburgh	244,995
38.	Virgie No. 2	New Madison	Byrne Coal & Coke Co.	"	9,534
39.	Arona	"	Keystone Coal Co.	"	14,750
40.	Edna No. 1	Edna No. 1	Hillman Coal & Coke Co.	"	148,930
41.	Greensburg No. 1	Greensburg	Keystone Coal & Coke Co.	"	28,261
42.	Greensburg No. 2	"	" " " " "	Pittsburgh and Redstone	166,589
43.	Armstrong	Radebaugh	Armstrong Bros. Coal Co.	Pittsburgh	2,781
44.	Greensburg No. 3	Greensburg	Keystone Coal & Coke Co.	"	2,106
45.	Hawksworth	"	Greensburg Coal Co.	"	312,205
46.	Crows Nest	"	Keystone Coal & Coke Co.	"	347,058
47.	Hempfield No. 1	"	" " " " "	"	170,628
48.	Daniels & Goldberg	"	Daniels and Goldberg	"	4,709
49.	Adamsburg	Adamsburg	Edward Tomajko	Redstone	80,000
50.	Betty	New Madison	Eisaman Coal Co.	"	6,775
51.	Forbes Road	Hannastown	Keystone Coal & Coke Co.	Pittsburgh	178,842
52.	Prospect	Radebaugh	Prospect Coal Co.	"	7,346
53.	Highland	Hannastown	Keystone Coal & Coke Co.	"	141,587

*Production figures from Pennsylvania Department of Mines.

PETROLEUM AND NATURAL GAS.

Origin of oil and gas.

Discussion of the theories of origin of oil and gas is not considered to come within the scope of this report. The theory that assigns an organic origin to all important accumulations of oil and gas is generally accepted today and the writer takes no exception to it. Pennsylvania petroleum and natural gas are thought to be largely, if not entirely, derived from the slow decomposition and distillation of plant remains, which were deposited in shallow water many million years ago, later covered by thousands of feet of other sediments, and were squeezed and heated by the pressure of these sediments and by crustal movements until the carbonaceous material was transformed into coal, oil, and gas. Differences in character of plant material as well as differences of conditions of deposition and subsequent squeezing and heating were the important factors in determining whether oil, gas, or coal was formed.

Accumulation of oil and gas.

Assuming the formation of the oil and gas to be essentially as outlined above, the next question to be answered is how did the oil and gas get to the sandstones and other strata in which they are found today; for it is quite generally believed that the oil and gas were not indigenous in such "sands" but have migrated to them from other strata. Opinion is still divided on this subject, but the following theory is perhaps most generally accepted.

The oil and gas are first formed as tiny globules of oil and bubbles of gas disseminated throughout the shale (originally mud) in which the carbonaceous material was deposited. Contemporaneous with and following the formation of the oil and gas, an increase in pressure, capillary attraction, or some other force, or probably several forces combined, moved the bubbles and globules of gas and oil through the rock. The constant tendency was for the oil and gas to work their way to the top of the stratum. Probably their lighter specific gravity, the fact that the rocks above were less compacted than those below, and the stronger capillary attraction of water were all instrumental in bringing this about. Eventually all of the oil and gas were forced out of the shale into the stratum above, which, if it happened to be a sandstone or conglomerate, would contain much more pore space and would permit the better separation of the oil, gas, and water. If the stratum were flat or only slightly tilted the oil and gas would be forced slowly along by the water and there would be little concentration of the oil or gas. Where oil and gas pools have been formed it has been found that there are always domes or some type

of closed structure in which the oil and gas have been arrested or halted in their progress and there concentrated. The oil, gas, and water would there naturally be separated according to their specific gravities.

The theoretical case just outlined does not mention many other factors which are frequently instrumental in determining the location of a pool, such as the change in the grain of the sand from point to point, slight variations in dip, etc., nor does it mention the case where there is no water in the sand or where there is neither oil nor water. It was given merely to illustrate the formation of oil and gas pools under the simplest conditions.

Structures.—The part structure has played in the formation of oil and gas pools in the Greensburg quadrangle is well illustrated in Plate XII. It can be plainly seen that the productive gas fields are along the Murrysville and Grapeville anticlines. The only oil pools in the quadrangle are down-structure from the Murrysville gas field and far up the pitch of the Duquesne syncline. Farther down this syncline water is encountered.

Convergence. Not enough data were at hand to draw convergence sheets of any of the sands in the quadrangle; however from a study of the data available it would appear that the maximum interval between the Pittsburgh coal and the top of the Murrysville sand, which is the one sand recorded by nearly all drillers, is at a point near Murrysville. The minimum is near a point two miles north-northeast of Jeannette. All of the well records available were carefully examined, those obviously inaccurate were discarded, and the remainder were used in compiling intervals, thicknesses of sands, etc. Some of the wells in the same district differed radically and yet so apparently were well-kept records, that it was not deemed wise to discard them nor yet to attempt working out intervals in small restricted areas. Instead, the logs of all wells in one township were averaged together. The results obtained may be considered as fairly accurate averages for those townships represented by a large number of well-records. The following table gives the interval from the Pittsburgh coal to the Murrysville sand in most of the different townships occurring in part or wholly within the quadrangle.

Average distance from Pittsburgh coal to top of Murrysville sand.

Township	County	Number of well records	Distance in feet
Plum	Allegheny	83	1880
Patton	Allegheny	34	1893
Washington	Westmoreland	28	1898
Franklin	Westmoreland	114	1918
Penn	Westmoreland	54	1867
N. Huntingdon	Westmoreland	25	1907
Bell	Westmoreland	4	1844
Salem	Westmoreland	50	1871
Hempfield	Westmoreland	135	1871

In compiling the above averages, the two greatest sources of error lay, first, in using an incorrect interval from the top of the well to the horizon of the Pittsburgh coal (most wells started at a stratigraphic horizon below the Pittsburgh coal), and second, in mistaking some other sand for the Murrysville.

Additional work since the above averages were compiled would seem to indicate that for some of the wells in the northwestern part of the quadrangle, the interval used from well mouth to the horizon of Pittsburgh coal was too large. It is believed nevertheless that the averages given are subject to an error of not more than 10 feet.

In the Greensburg quadrangle the sands are fairly regular and usually the drillers named them correctly. However there were exceptions. In some places the Berea and Murrysville sands are almost joined, and in such areas the drillers sometimes mistook the top of the Berea for the top of the Murrysville. In other areas the Murrysville is split and the lower half was termed Hundred Foot by the drillers. It was usually possible to detect and correct the latter mistake however.

The following table of intervals from the base of the Pittsburgh coal to the different sands, is an attempt at an average for the whole quadrangle (see appendix).

Table of oil and gas sands in the Greensburg quadrangle.

System	Sub-system	Series	Groups	Geologic name	Drillers' names	Interval from base of Pittsburgh coal to top of stratum	Average thickness
						Feet	Feet
CARBONIFEROUS	Pennsylvanian	Pittsburgh	Mon.	Pittsburgh coal	Pittsburgh coal	0	
			Conem.	Saltsburg sandstone	Little Dunkard sand	400	50
				Mahoning sandstone	Big Dunkard sand	570	75
			All'y.	Upper Freeport coal	Freeport coal	660	0–7
		Potts-ville		Homewood sandstone	Gas sand	940	30
				Conoquenessing sandstone	Salt sand, Sixty-foot sand	990	60
	Mississippian	Mauch Chunk		Mauch Chunk red shale	Red rock	1,115	15
				Greenbrier limestone	Big lime	1,130	25
		Pocono	Burgoon	Loyalhanna limestone	*Big lime, Seventy-foot	1,160	40
				Burgoon sandstone	Big Injun, Seventy-foot and Big Injun, Mountain sand	1,200	340
			Cuyahoga	Patton shale	Red shale	1,580	10
				Sharpsville sandstone	Squaw sand, First sand	1,620	70
			Berea	Berea (Corry) sandstone	Berea grit, *Thirty foot, Murrysville stray sand	1,820	30
DEVONIAN	Upper Devonian		Conewago or Catskill		Murrysville sand, *Salt sand, *Gas sand	1,880	110
					Hundred-foot sand	2,000	100
					Thirty-foot sand	2,120	40
					Red shale	2,230	250
					Third sand, Gordon sand	2,350	20
					Fourth sand	2,420	25
			Chemung		Fifth sand	2,480	40
					Sixth sand, Bayard sand	2,550	30
					Elizabeth sand	2,620	20
					First Warren(?) sand	2.830	15
					Second Warren sand	2,950	15
					Speechley stray sand	3,220	20
					Speechley sand	3,300	25
					Tiona sand	3,420	15
			Portage		Sheffield (Gartland?) sand	3,550	10
					First Bradford sand	3,840	25
					Second Bradford sand	3,960	15
					Kane sand	4,030	10

Description of sands.

Of the different sands and members given in the table, some are much more readily recognized by the drillers than others. The best "markers" are the Pittsburgh coal, Upper Freeport coal (where thick), Big Injun, Murrysville, Speechley, and Bradford sands, and the red beds just below the Thirty-foot sand. The Mauch Chunk and Patton red shales, particularly the former, constitute good markers in certain parts of the quadrangle, but unfortunately are either thin or missing in other parts.

The sands above the Big Injun in this region are unimportant. No oil and very little gas has been found in any of them. The Big Injun sand is a hard, light-colored, medium-grained, thick sandstone, often split by a few feet of shale into the so-called Seventy-foot sand and a lower, thicker sandstone called Big Injun by the drillers. Since the two sandstones are combined in many places, and since further it is believed that the so-called Seventy-foot sand is a part of the Burgoon member, the Seventy-foot sand is considered in this report as merely a part of the Big Injun. Frequently the Big Injun sand is water-bearing and must then be cased off. It has been proven that the sand is gas-bearing at places along all three major anticlines (see Plate XII), and "shows" of oil have been found in it at several points.

Below the Big Injun is the Squaw or First sand. It is usually dry, only small quantities of gas having been found in it in a few wells. It is hard, gray, and often contains water.

The Berea grit is recorded occasionally in well records as a hard, dark sand, occurring just above the Murrysville sand. Study of the well records at hand would seem to show that the Berea and Murrysville are not the same sand, as has been previously supposed. Production from the Berea in this quadrangle is negligible.

The most prolific sand in the quadrangle is probably the Murrysville. Wells drilled to this sand have furnished many million cubic feet of gas daily ever since the first well pierced it in 1878. It is usually a light-colored, open-grained, "soft" sandstone (soft in comparison with those above and below) which frequently contains both gas and water. The water is particularly troublesome southwest of Lyons Run. As noted in the table the sand averages slightly over 100 feet thick and is separated from the harder Hundred-foot sand below by a thin bed of shale.

The Hundred-foot sand derived its name from its thickness, a persistent 100 feet. Described sometimes as a white and sometimes as a dark sand, it is always a good, hard sandstone of fine to open grain. It is frequently water-bearing, but is also the source of much gas. In the Plum Creek Church district it has been found to contain both gas and oil.

The Thirty-foot sand is a hard, light-colored sandstone which does not seem to be very persistent but which occasionally is found to contain gas under good pressure. It is just above the thick Catskill red beds.

The correlation of the Third, Fourth, Fifth, Sixth and Elizabeth sands was found to be practically impossible since so many of the records gave the position of only one or two of these sands and grouped the rest (if there were any) under "slate and shells." It was finally decided that for purposes of correlation the first sand close beneath the Catskill red beds would be called the Fifth sand; that is, the Third and Fourth sands come within the red beds and are themselves usually stained red. The last mentioned sands hardly ever contain gas in commercial quantities and are of relative unimportance. The Fifth, Sixth, and Elizabeth sands, however, are important reservoirs of gas in certain areas. No oil of consequence has been found in any of these sands, although "shows" of oil are reported in several wells. These sands are all hard and thin, and usually light-colored.

Water is seldom encountered in any of the sands below the Hundred-foot.

Between the group of thin sands just described and the Speechley group is a thick series of shales and occasional thin sandstones. The latter are unimportant and seldom contain even a show of gas. This great thickness of rock, some 600 feet, is very often recorded in well records simply as "slate and shells".

The Speechley Stray sand is of greatest importance in Plum township where a small oil pool was developed in 1917. Considerable gas has also been obtained from this sand, particularly in Hempfield township, south of the main line of the Pennsylvania Railroad. The sand is typically chocolate-colored and has medium hardness and texture.

The Speechley sand is similar in appearance to the Speechley Stray, but occurs at a lower horizon and in this quadrangle never has been found to contain oil. In the northwestern part of the quadrangle it contained gas along both flanks of the Murrysville anticline. Occasionally a third and even a fourth sandstone occurs in the Speechley group, but production is never obtained from more than one sand in any one locality.

The Tiona sand is productive chiefly in the Grapeville district. It is described variously in the drill-records as a soft, chocolate-colored sand and as a white, pebbly sandstone. Like the Speechley it is a thin, open-grained sandstone, but it does not appear to be so widespread as the former.

From the Tiona to the First Bradford sand is another long interval of shales and unimportant, thin and local sandstones. All of the

sands of the Bradford group are dark-colored, usually open-grained and they often contain gas where structural conditions are favorable. No one of the group is persistent except locally, but one or the other is found in nearly all of the deep holes drilled in the quadrangle.

Already many wells are producing from some one of this group of sands and it is likely that in the future a greater proportion of wells will be drilled to this and even deeper sands to furnish a continued supply of natural gas.

Description of oil and gas fields.

Fayette anticline. Folding along the Fayette anticline seems to have been too intense for the formation and accumulation of oil. Gas has been found along the anticline but never as yet in large quantities in this quadrangle. The only wells drilled on this anticline in the Greensburg quadrangle, got small gas production from the upper sands. At least one of them, that on the Alex Young farm, about three miles southeast of Greensburg, got a good flow of gas at a depth of 2100 feet, but it was soon drowned out by salt water.

Grapeville anticline. The Grapeville anticline is a gas reservoir throughout much of its length in the Greensburg quadrangle. The first drilling on this structure was done in 1886 when several wells were put down to the Murrysville sand in the vicinity of Grapeville. Since that time every sand down to and including the Bradford has been tested by deep holes along the entire length of the anticline. Production has been obtained from nearly all of the sands at one point or another, but perhaps the most prolific sand has been the Tiona in the Grapeville district. A large pool has been developed in the Bradford sand southeast of Claridge. North of this pool, most of the production has come from the Venango group of sands (those just below the Catskill red beds). Near Arona a good pool has been developed in the Speechley sand. Initial rock pressures of over 1200 pounds have been reported from wells in this pool. Many of the wells now producing from one of the lower sands started off with initial pressures of over 500 pounds and initial volumes of 3,000,000 cubic feet or more. The quantity of gas already obtained from wells along this anticline must be many billion cubic feet.

Murrysville anticline. Like the Grapeville anticline, the Murrysville anticline has been proved to contain gas throughout its length in this quadrangle. With the exception of one or two small areas most of the producing wells are near the axis of the anticline, although there are a few producing wells in Bell township which are rather far down the slope and many others on the northwest flank of the anticline and north of Murrysville. Gas has been obtained from nearly all of the sands but by far the greater part of it has come from the Murrysville. The Haymaker No. 1 well on the Remaley

farm near Murrysville was completed and came in with a roar November 3, 1878. The enormous volume of gas from this well (after blowing off for many months) finally attracted the attention of the public to the Murrysville field and since that time nearly every square mile of land along the anticline has been drilled in search of a further supply of gas. The rock pressure of most of the early wells completed in the Murrysville sand was between 300 and 400 pounds. The initial volume was often several million cubic feet. Later drilling disclosed the fact that the deeper sands were also productive along the anticline and large production is being obtained now from the Speechley and the Bradford sands as well as from the Venango group and the Hundred foot. The increased cost of deeper drilling is largely compensated for by the higher rock pressure and the increased "staying power" of the wells.

Duquesne syncline. The only oil pools in the quadrangle are in the Duquesne syncline, down structure from the gas in the Murrysville anticline, but far up the pitch of the syncline. All of the producing wells are between the 1200 and 1250 foot structure contour lines. The Hundred-foot pool is in the bottom of the syncline, the long axis of the pool being almost at right angles to the axis of the syncline. Drilling in this pool was revived in 1922 when a well drilled by the T. W. Philips Gas and Oil Co. on the T. E. Mallisee farm came in with an initial production of nearly 1400 barrels a day of high gravity oil. Unfortunately this proved to be only a "flash in the pan" and within nine months drilling in this pool had stopped.

The Speechley Stray oil pool is near the southeast end of the Hundred-foot pool and has never produced oil in large quantities. The long axis of this pool parallels the axis of the Duquesne syncline, but the pool is so small that it does not extend to the 1250 foot contour line at the upper end, nor beyond the 1200 foot contour down the structure. The largest wells in the pool came in with initial productions of less than 30 barrels per day. The pool was opened in 1917 but drilling soon ceased. The wells are long-lived however and many of them are still producing a small quantity of high-gravity oil.

Production.

Production figures. No data are available as to the production of either oil or gas in the Greensburg quadrangle alone. However, some idea of the enormous gas production may be obtained from the estimate of John C. Carll of the Second Pennsylvania Geological Survey who figures that in four years 1885 to 1888, over 438,000,000,000 cubic feet of gas were drawn from the Murrysville field alone. Including production from the Grapeville anticline, it is probably safe to assume that the average for the years from 1888 to the present has been if anything greater than the production that

Carll assumed. If we assume his rate, then a production of over 3,700,000,000,000 cubic feet of gas has been obtained from this quadrangle alone. At $0.10 per thousand cubic feet, the value of the gas produced would amount to $370,000,000.

The quantity of oil produced has been so small as not to compare in value with the gas. To obtain some idea of its value let us assume that there have been 15 producing wells with an average production of three barrels a day for five years. At an average price of $4.00 a barrel, the total value of the oil produced would be about $328,000. Surely an insignificant sum when compared with the total value of the gas.

Life of oil and gas wells. Oil was discovered in 1912 in the vicinity of Plum Creek Church and nearly all of the wells drilled since then are producing. The production of the older wells has fallen off about 90 per cent in ten years. Judging from the life of wells in nearby oil fields, wells in this pool are good for ten or fifteen years further production, possibly more. As is well known, the decline in production of oil wells is fairly rapid at first, the rate of decrease becoming slower each year. The oil fields of Pennsylvania are noted for their staying-power, i. e. the comparatively slow rate of decrease in production, hence the estimate of fifteen years additional production may prove conservative.

Many gas wells in the Greensburg quadrangle have been producing for twenty years or more. When compared with the rapid decline in production of some pools (the Cleveland and McKeesport pools for example), the long productivity of such wells is remarkable. In the Murrysville region most of the old producers are of course now abandoned, but here and there old wells are still producing gas enough to warrant keeping them in the line. Similarly a well drilled on the W. J. Byer's farm near Grapeville and located on the Grapeville anticline, has been producing gas from the Hundred-foot sand for over twenty-five years. The long life of these gas wells is due, (1) to the texture of the sand, which is compact and fairly close-grained (when compared with sands in other fields throughout the world), and (2) to the fact that wells have not been drilled too closely together. The latter reason is more important of the two and it in turn is due to the fact that there are few communities in the gas-producing territory and consequently the large gas companies which have done most of the drilling in this area were able to obtain leases on fairly large acreages. Thus they were able so to space their wells as eventually to exhaust the gas from any lease with a few carefully located wells, instead of having to drill many wells close together in order to protect the lease. Naturally the fewer wells, the longer the supply of gas will last.

It is difficult to estimate the average life of gas wells in this quadrangle from the rather meagre data at hand. Ten years would perhaps be a conservative estimate. Many of the old wells still producing, however, would doubtless have been abandoned before now had they not been deepened to some lower producing sand. The cleaning-out of the wells has also often revived them sufficiently to make them last for several years more.

Although none of the wells drilled to the Bradford sand has outlived the old wells still producing from the Murrysville or Hundred-foot sands it is believed that in the long run the deeper wells will have a longer average life than wells sunk only to the upper sands. The reason is that wells sunk to the deeper sands usually have a higher rock pressure than those drilled to shallow sands, and for any given storage capacity, the higher the pressure, the greater the quantity of gas stored and the longer it will take to exhaust that supply. It is assumed that the lower sands are in general as fine-grained as the upper sands.

Proportion of productive wells. Drilling wells for oil and gas is a business for men or companies with large resources. Even in recognized producing territory the proportion of dry holes is so large that the individual or small company with capital enough to sink only one well is apt to drill a dry hole and the venture is disastrous. In wildcat territory the chances of drilling a "duster" are manifestly much greater. However, a company which is large enough to drill a dozen or more wells will probably obtain enough production (if the wells are carefully located) to pay for the cost of two or three dry holes. A company which is large enough to employ competent men and drill several dozen wells a year is as sound and safe a business organization as any other.

In drilling for gas in Pennsylvania over a period of seven years the proportion of dry holes to producing wells was one in five. In the Greensburg quadrangle the proportion has been about two dry holes out of every eleven drilled. This proportion is more apt to increase than decrease in the future as prospecting for further supplies of gas will necessarily be limited to the less favorable structures, all the more obviously favorable strutures having been tested already.

Disposal of oil and gas. The small quantity of oil produced in the Plum Creek Church pools is easily handled by the pipe lines that were long ago laid to that area. The flush production recently obtained in the Hundred-foot sand was handled probably by storing in tanks until it had dropped to a point where the pipe lines could take the entire output of the wells.

Only a very small percentage of the gas produced in the Greensburg quadrangle is used locally. Probably ninety per cent is piped away and consumed in Pittsburgh and nearby industrial centers. Much that is used in the quadrangle is consumed by domestic users in the various towns supplied with natural gas, especially in Greensburg and Jeannette. The remainder is consumed in various manufactories such as brick plants, glass plants, etc.

The first pipe line to the Murrysville field was laid in 1882. Since then many trunk lines and hundreds of small lines have been laid, so that today the quadrangle is literally criss-crossed with them and any new gas pools could be quickly turned in to some trunk line.

Future Development.

Favorable locations. The upper sands in the Greensburg quadrangle have been thoroughly tested with the drill. Only a few areas of any promise remain. Of those areas as yet untested the most promising seem to be: (1) the saddle between the Irwin and Elders Ridge synclines, and (2) the southeast flank of the Murrysville anticline between those wells already drilled in Bell township and those to the west in Washington township. Other small areas remain to be tested but will doubtless be drilled as fast as companies holding the leases require further production.

The possibility of finding any other gas pools is extremely remote. Equally improbable is the finding of other oil pools. Inasmuch as the quadrangle has been thoroughly punctured with drills, the possibility of finding some heretofore undiscovered producing sand (except by very deep drilling) is practically out of the question.

Deeper drilling. Deeper drilling is one loop-hole by which it may be possible to avert a gradual diminution in the supply of gas from this quadrangle. Many old wells have been rejuvenated by drilling them deeper. Many other old wells can be made to furnish an increased supply of gas in the same manner. Almost the only remaining hope of large new production is the possibility of getting gas in still deeper sands than those already tested. The fact that gas has been found in the Oriskany (?) sand at Ligonier, many miles to the east, makes it seem likely that it would also exist in the Oriskany in this quadrangle, provided the Oriskany extends that far west (and it seems probable that it does). To penetrate the Oriskany with the drill, a well located at Jeannette would have to be put down about 7300 feet. The cost of such a deep well at present prices would be prohibitive, but the time may come when the selling price of natural gas will be so much higher that a good well in the Oriskany would pay for itself.

There is also the possibility of striking productive sands between the Bradford sand and the Oriskany. Farther north several sands

within a distance of five hundred feet below the Bradford are productive. None of these have as yet been thoroughly tested in this area. However, tests already made are not very encouraging.

Lastly, it is believed that not nearly enough drilling has been done along the Fayette anticline to condemn it completely. So far as is known, only one well drilled on this anticline in this quadrangle was deep enough to test the lower sands. Judging from the steepness of the structure, it is quite possible that the upper sands were fractured sufficiently to permit the escape of any gas that might have been contained in them, but that does not mean that the lower sands might not contain large quantities of gas. If they do contain gas it is probably under very high pressure.

Character and composition of oil and gas.

Analyses of natural gas. Natural gas and petroleum are both mixtures of hydrocarbons of different composition and specific gravities. The proportions of the different compounds are not fixed as in a chemical compound but may and do vary greatly. Gas from different sands will usually differ in the proportions of the constituent hydrocarbons, whereas gas from the same sand may have approximately the same composition throughout large areas.

Investigations and analyses of natural gas are conflicting in their testimony, few investigators having arrived at the same results. The most careful work seems to show, however, that methane (CH_4) is the important constituent of natural gases, that nitrogen is nearly always present as a diluent, and that the remaining constituents of natural gas seldom constitute more than one per cent of the total volume.

In 1875 an analysis of gas from a well at Leechburg from what very likely was the Murrysville sand, was published in Vol. L of the Second Pennsylvania Geological Survey. The analysis was made by Samuel P. Sadtler.

Analysis of gas from Leechburg well, Westmoreland Co.

Carbonic acid (HCO_3)	.35
Carbonic oxide (CO_2)	.26
Illuminating hydrocarbons	.56
Hydrogen	4.79
Marsh gas (methane, CH_4)	89.65
Ethyl hydride (ethane, C_2H_6)	4.39
Propyl hydride (propane, C_3H_8)	trace
	100.00

The calculated specific gravity of the above gas was given as .5580 which seems rather low.

In Technical Paper 109 of the U. S. Bureau of Mines analyses of gas from different sands encountered in a well near Trafford City are given. The well is near the boundary between the Pittsburgh and Greensburg quadrangles.

Analyses of natural gas from near Trafford City, Westmoreland Co.

Constituents	Murrysville sand. Depth 1700 feet.	Elizabeth sand. Depth 2295 feet.
Carbon dioxide	trace	trace
Methane	98.8	94.0
Ethane		5.2
Nitrogen	1.2	.8

Four analyses of gas from the Murrysville sand quoted from various sources on page 244, Vol. IX, 1908, of the University Geological Survey of Kansas, are interesting as showing the different results obtained by different analysts. As explained on the same page the considerable variation in the results is probably due to the different methods of analysis employed, rather than to actual change in the composition of the gas. The last two analyses given are probably the most reliable.

Analyses of natural gas from Murrysville, Pa.

	1	2	3	4
Carbon dioxide			0.28	0.20
Carbon monoxide	1.00			
Heavy hydrocarbons	0.50			
Methane	95.20	78.24	97.70	95.40
Hydrogen	2.00	19.56		
Oxygen	1.30	2.20	Trace	Trace
Nitrogen			2.02	4.40
	100.00	100.00	100.00	100.00

Of the work that has been published, the best and most careful seems to have been done by F. C. Phillips for the Second Geological Survey of Pennsylvania in 1887. The following table gives the results of analyses of gases from other parts of the state as well as from the Greensburg quadrangle.

Analyses of Pennsylvania natural gases.

[Francis C. Phillips, Analyst.]

Constituents	1 Sheffield, Warren Co.	2 Kane, McKean Co.	3 Wilcox, McKean Co.	4 Speechley sand near Oil City	5 Lyons Run, Murrysville	6 Raccoon Creek	7 Houston, Washington Co.	8 Murrysville, Westmoreland Co.	9 Pittsburgh Exhibition Grounds	10 Creighton, Allegheny Co.	11 Painter & Co's well near Pittsburgh	12 Baden, Beaver Co.	13 Allegheny City salt well
Nitrogen	9.06	9.79	9.41	4.51	2.02	9.91	15.30	4.40	7.30		0.70	12.32	7.10
Carbon dioxide	0.30	0.20	0.21	0.05	0.28	trace	0.44	0.20	0.52	3.64	0.40	0.41	0.30
Oxygen	trace	trace	trace	trace	trace	trace	trace	trace	trace			trace	
Hydrogen sulphide						trace							
Paraffins	90.64	90.01	90.38	95.44	97.70	90.09	84.26	95.40	92.18	96.36	98.90	87.27	92.60
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Composition of above paraffins by weight													
Carbon	76.69	76.77	76.52	77.11	74.96	76.42	76.68	75.15	75.40	75.80	75.51	76.48	75.44
Hydrogen	23.31	23.23	23.48	22.89	25.04	23.58	23.32	24.85	24.60	24.20	24.49	23.52	24.56

Nos. 1, 2, 3, 4, 5, 6, 7 and 12 are from Pa. Second Geol. Survey, Ann Report, 1886, p. 815.
Nos. 8, 9, 10, 11 and 13 are from Am. Chem. Jour., vol. 16, p. 416, 1894.

The foregoing analyses show the high percentage of methane in gas from the Murrysville sand. The percentage of nitrogen is small and impurities such as carbon dioxide and oxygen are almost negligible.

Heating value of natural gas. The heating value of natural gas is usually expressed in this country as so many British thermal units per cubic foot of gas. The quantities of other fuels necessary to furnish the same heating energy as is contained in 1000 cubic feet of Pennsylvania natural gas are given below:

Heating equivalent of 1000 cubic feet of Pennsylvania natural gas.[11]

Manufactured gas	2,000 cu. ft.
Gasoline	9 gallons
Kerosene	8½ "
Alcohol	15 "
Electricity	322 kw. h.

At its present price natural gas compares very favorably with other fuels. Also it is clean and easily handled, so that altogether it constitutes an ideal fuel.

[11]Wyer, Samuel S., Manufactured Gas and Natural Gas Situation in Pennsylvania, p. 11, January, 1922.

Oil.—Petroleum from Pennsylvania fields has always commanded a higher price than that from other parts of the United States because (1) it is a paraffin base oil and the residuum left in the process of refining is small; (2) its high gravity (over 40° Beaume); (3) the high gasoline extraction obtainable and the low percentage of impurities; and (4), because of its nearness to points of consumption.

Oil from the Plum Creek Church pools is of very high gravity and has good lubricating qualities. A sample of oil from the Hundred-foot pool was analyzed by Mr. N. A. C. Smith of the U. S. Bureau of Mines. His complete report is here given.

Analysis of oil from Plum Creek Church.

Sample Number 1029.

Pennsylvania — Plum Creek Church pool — Allegheny County

Specific gravity, 0.817 — A. P. I. gravity, 41.7°
Per cent sulphur, 0.19 — Per cent water, Nil
Saybolt Universal viscosity at 70° F.—62
Saybolt Universal viscosity at 100° F.—51
Pour test, 28° F.

Distillation, Bureau of Mines Hempel method.

Air distillation, Barometer, 745mm. First drop, 27° C. (81° F.)

Temperature °C.	Per cent cut	Sum per cent	Sp. gr. cut	°A. P. I. cut	Viscosity	Cloud test °F.	Temperature °F.
Up to 50							Up to 122
50 - 75							122 - 167
75 - 100	5.8	5.8	0.680	76.6			167 - 212
100 - 125	4.3	10.1	.724	63.9			212 - 257
125 - 150	4.2	14.3	.742	59.2			257 - 302
150 - 175	4.9	19.2	.759	54.9			302 - 347
175 - 200	4.6	23.8	.768	52.7			347 - 392
200 - 225	5.1	28.9	.779	50.1			392 - 437
225 - 250	5.3	34.2	.794	46.7			437 - 482
250 - 275	6.4	40.6	.800	45.4			482 - 527
Vacuum distillation at 40 mm.							
Up to 200	4.9	4.9	.826	39.8	40	23	Up to 392
200 - 225	6.5	11.4	.830	39.0	45	43	392 - 437
225 - 250	7.9	19.3	.841	36.8	56	59	437 - 482
250 - 275	5.8	25.1	.845	36.0	68	77	482 - 527
275 - 300	6.2	31.3	.854	34.2	95	95	527 - 572

Carbon residue of residuum—0.6 per cent.

Approximate Summary.

	Per cent	Sp. gr.	°A. P. I.	Viscosity
Gasoline and naphtha	23.8	.736	60.8	....
Kerosene	16.8	.792	47.2	....
Gas oil	11.5	.828	39.4	....
Light lubricating distillate	7.8	.833-.856	38.4-33.8	50-100
Medium lubricating distillate	2.0	.856-.859	33.8-33.2	above 100

Mr. Smith's letter containing the report of the analysis reads in part as follows: ———"I am inclosing an analysis of this oil which shows that it is very similar to other oils produced in Pennsylvania. From the light color of the crude and the very low carbon residue figure, it would seem that this oil would be particularly suitable for the manufacturer of high grade cylinder stocks."

Waste of Natural Gas.

Much has been said about the waste of natural gas, but it is doubtful if one tenth of the general public which uses this commodity has fully appreciated the amount of this loss and the large proportion of it which could be prevented.

In the early history of oil and gas development in Pennsylvania, gas was deemed of little value and when it was found in the search for oil, the well was usually left uncapped and the gas allowed to escape in the air. Untold quantities of gas were lost in this way. Later, laws were passed to enforce the plugging of all abandoned wells and this tremendous economic waste largely halted. Of more importance than the passing of the law was the realization by men interested in the production of gas that such uncapped wells were draining sands of gas that might well be turned into their lines.

In former years much gas was also lost through the wasteful practice of blowing-off wells that were improperly cased and troubled by water. As the value of natural gas has become better appreciated and the diminishing supplies of this natural resource have been forcibly brought to the attention of the public, this, and other such wasteful practices have been largely discontinued.

The letting of contracts to supply gas at a fixed price per month without putting any limit on the amount used, formerly caused a large wastage of gas. Since the price of gas was the same whatever the amount used, people deemed it simpler to open a window in order to cool off the house, than to lower the flame of the gas burner in the furnace. Such contracts are fortunately now a thing of the past.

Other wasteful practices which are rapidly being corrected are: (1) improper and careless tubing of wells; (2) the use of inefficient boilers for drilling; (3) failure to repair leaks in gas lines, etc.

Perhaps the largest waste at the present time is caused by the use of inefficient burners and high pressure (3 inches of water or over) gas for cooking. By using efficient burners, properly adjusted, and a pressure of only one inch, double the amount of cooking could be done with the same amount of gas. Similarly it has been found by actual experiment that open grid stoves with properly adjusted burners give nearly four times the efficiency of solid top stoves with low-set burners.

Value of good well records.

In closing the chapter on oil and gas, the author wishes particularly to call the attention of everyone interested in any way with the production of either oil or gas, to the great value of accurate

and detailed well records. Good well records enable the geologist to correctly correlate the strata in different wells, and to draw an underground structure map which will show any divergence between surface structure and underground structure. Scientific location of future wells depends on this. Of equal benefit to those paying for the drilling is the better knowledge of the depths to the sands, to production, etc., which enables them to estimate more closely the amount of casing and tubing needed and to make all preparations before drilling into the expected "pay" streak. In "shooting" a pay streak, the exact depth must be known in order to make the "shot" effective. The use of mechanical measuring devices such as are now on the market is strongly recommended by the writer.

Acknowledgments.

To the large gas companies operating in this quadrangle I am indebted for most of the accurate and detailed records which were used in preparing this report. These companies long ago realized the importance of good well records and insisted on drillers making logs of all wells. Only a few of the small operators now ram down a hole without regard for what it passes through so long as they can get the hole down in a hurry.

CLAY AND SHALE.

Fire clay.

Inasmuch as no known tests have been made to determine the fusibility of the different clays occurring within the Greensburg quadrangle, it is not known whether or not any of them would make good refractory brick. Some of the clays exposed have the typical, nodular appearance of flint clays, but until actual fire tests have been made, the value of these clays as refractories will remain problematical.

All of the coals occurring within the quadrangle have clay associated with them, although it is much more characteristic and persistent association with some than with others. Thus the "draw slate" of the Pittsburgh coal bed averages about 11 inches thick for mile after mile, varying, it is true, but always present and separating the roof division from the main bed. The under clay of the Pittsburgh bed is less constant. It is seldom over six inches thick and may not be present at all. The clays associated with the other coals are similar in their variability, that beneath the Redstone perhaps being the most persistent.

Certain other horizons in both the Monongahela and Conemaugh groups are characterized by the frequent occurrence of clay beds. Thus clay beds are common in the Benwood member of the Mono-

gahela and sometimes attain a thickness of ten feet or more. In the Conemaugh group clay beds frequently occur between the Connellsville and Morgantown sandstones, beneath the Ames limestone, and above the Lower Mahoning sandstone. They occur sporadically at many other horizons (see detailed sections).

In nearby regions, notably at Salina on Conemaugh River, the clay occurring a short distance beneath the Upper Freeport coal and known as the Bolivar fire clay, is being mined and manufactured into fire brick of good quality. This same clay doubtless underlies the Upper Freeport coal throughout large areas in the Greensburg quadrangle.

Analyses of Bolivar fire clay from Kiel Brothers' mine, Salina, Pa.[12]

Sample number	957	956a	956b	956c	956d
Silica	51.920	47.250	40.720	60.520	55.330
Alumina	31.640	34.350	37.280	24.970	27.841
Protoxide of iron	1.134	.693	2.448	1.650	2.916
Titanic acid	1.160	1.990	2.280	1.220	1.140
Lime	.030	.580	.520	.910	.580
Magnesia	.443	.090	.002	trace	.756
Carbonic acid	none	.455	.408	.725	.455
Alkalies	.402	.261	.570	.218	3.916
Water	13.490	13.695	15.002	9.395	7.495
	100.219	99.364	99.230	99.608	100.429

Sample No. 957. Hard and brittle; irregular fracture.
956a. Top stratum. Hard and brittle; irregular fracture.
956b. Middle stratum. Hard and brittle; very irregular fracture.
956c. Bottom stratum. Hard and brittle; conchoidal fracture.
956d. Plastic clay. Comparatively soft; irregular fracture.

All of the specimens were of a dark, pearl gray color.

Surface and residual clays.

The quantity of surface and residual clays in this quadrangle is small. The surface clays occur as thin deposits along the streams and usually are of very small extent. The largest deposits of residual clay seen by the writer are on the broad tops of some of the hills in the Irwin and Greensburg basins where some of the thick limestone beds in the Benwood member have weathered and the lime leached out, leaving a yellow sticky, fairly pure clay. It is believed that the deposits are not very thick. Road cuts through such hilltops usually expose a mantle of less than six feet of soil and clay.

Clays and shales suitable for the manufacture of brick.

This quadrangle contains an almost inexhaustible supply of material suitable for the manufacture of common building brick. Many of the shales and clay beds outcropping in the quadrangle are suitable for such a purpose either alone or when mixed with

[12]Pennsylvania Second Geol. Survey, report M 2, pp. 259-260, 1879.

some other shaly or sandy bed, as the chemical composition of ordinary brick ranges within fairly wide limits. The chief requisite in brick-making is that the material be plastic enough to mold and yet not contain enough kaolin to cause excess shrinkage and cracking. It also should not contain any material which would cause an efflorescence to form on the brick.

One of the largest shale quarries in the quadrangle is the one owned by Wymer & Starr of Turtle Creek, Pa., and located just north of Blackburn on the Turtle Creek branch of the Pennsylvania Railroad. Formerly both the Pittsburgh red beds (beneath the Ames limestone) and the Schenley red beds (beneath the Morgantown sandstone) were quarried here and used in the brick plant at the foot of the quarry for making common red brick.

At present only the upper bench is being worked and stripping has been carried back 135 feet to a point where the "cover" is 60 feet thick. This upper bench (Schenley red beds) consists of 17 feet of structureless clay, underlain by 6 feet of clay shale.

The material is blasted out, trammed to the edge of the quarry and dumped into a chute leading directly into the mill. There it is ground, water added, and the material mixed and molded by machines. The molded brick are stacked by hand on small trucks which are then run into the driers. These are gas-fired ovens in which the wet brick are slowly heated and a large percentage of the contained moisture driven off. The bricks are left in the ovens for about 24 hours and are then stacked in the kilns for burning. These kilns are of the round, down-draft type and are also gas-fired. The process of burning the brick takes about nine days after which they are allowed to cool slowly for 6 days. The finished brick are then ready for the market.

The following flow-sheet is illustrative of the practice followed at most of the modern brick plants in this district.

Another important shale quarry is that owned by the Jeannette Brick and Stone Co., and located at Grapeville Station between Jeannette and Radebaugh. The material used here is the Lindsey shale and the clay soil which lies above it. The two materials are quarried at the same time by steam shovel and when mixed and burned make a good grade of common red brick. Face brick is made from the same materials by using a special die and burning them a little differently in the kilns.

A third large quarry is at the top of the hill just north of Huff, Hempfield township. The Keystone Clay Products Company has a steam shovel in operation at this quarry and is mining the shale just above the Redstone coal. The material is used in making brick.

There are many other smaller shale quarries in the quadrangle,

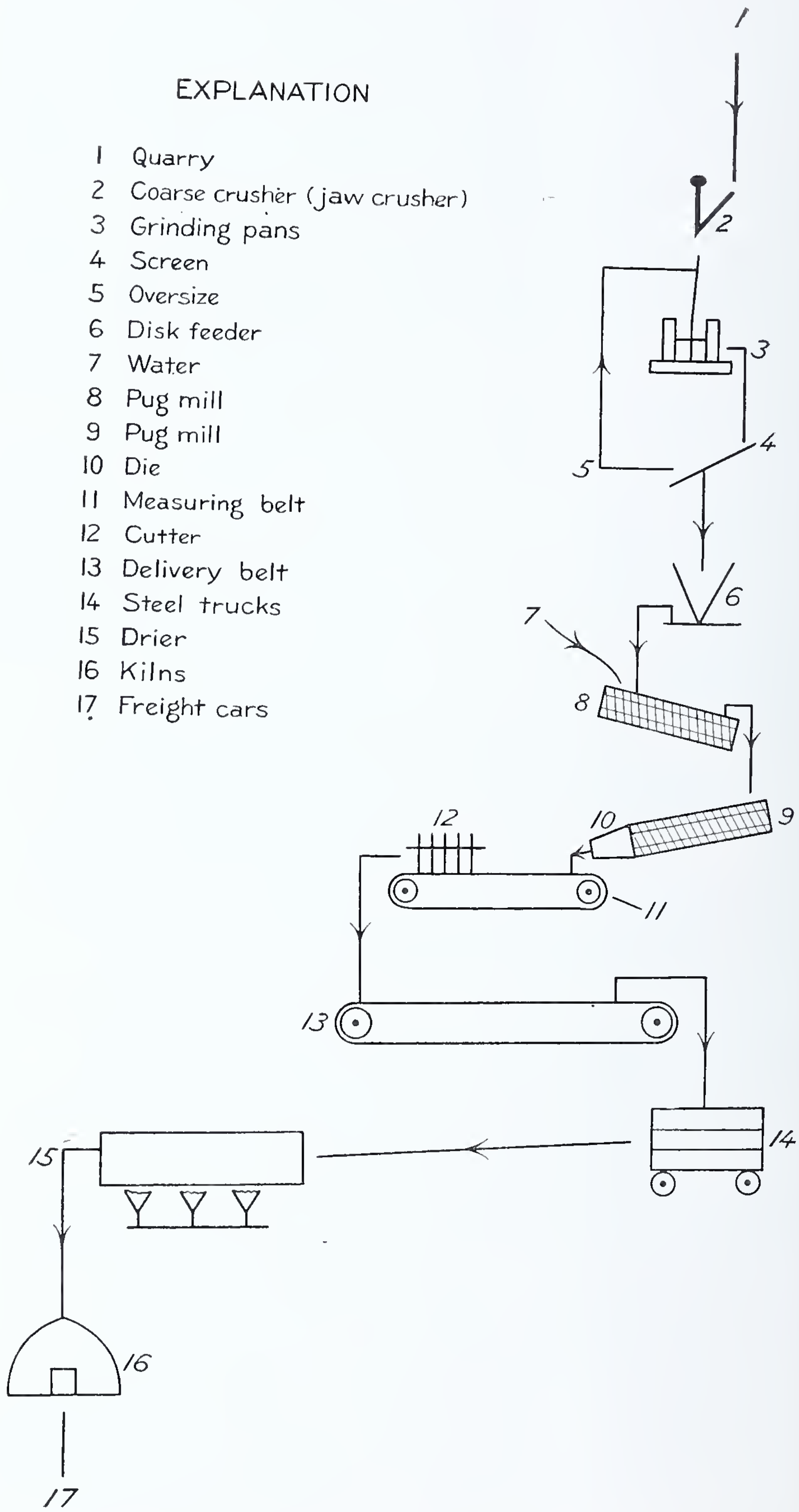


Fig. 21. Flow sheet of modern brick plant.

FIGURE 22. Key map showing location of clay and limestone sections.

but those mentioned above are the only ones known to be operating in 1923.

Doubtless many of the clays and shales occurring within the quadrangle are suited for the manufacture of paving brick as well as for the many types of face brick now in use, but as yet there has been little production of such brick.

Fig. 23 shows the thickness of some of the clay beds in different parts of the quadrangle. The points where the sections were measured are shown on the key map, Fig. 22.

Some of the records of diamond drill-holes put down in the quadrangle show thickness of fire clay at different horizons in and below the Conemaugh group. The fact that no such thicknesses (one record showed 30 feet of fire clay under the Brush Creek coal) occur at the surface makes the author seriously doubt the reliability of some of these records and he considers it prudent not to publish them.

Figure 23.

Clay sections.

1. Colvin Run limestone horizon, quarry $\frac{1}{2}$ mile south of B. M. 1033 on Lincoln Highway (Philadelphia and Pittsburgh Pike) east of Irwin.
2. Mount Morris limestone horizon, outcrop 600 yards north of Chambers, North Huntingdon township.
3. Waynesburg coal horizon, outcrop $\frac{1}{2}$ mile south of Lindencross, North Huntingdon township.
4. Waynesburg coal horizon, outcrop $\frac{3}{4}$ mile southeast of Hannastown, Salem township.
5. Upper part of Benwood limestone horizon, outcrop at Dick, Sewickley township.
6. Lower part of Benwood limestone horizon, outcrop at Norwin High School, Irwin.
7. At base of Benwood limestone, exposed in cut of Pennsylvania Railroad $\frac{1}{5}$ mile east of the station at Irwin.
8. At base of Benwood limestone, outcrop $1\frac{1}{4}$ miles east-northeast of Export, Franklin township.
9. Redstone clay, outcrop in stream bank $\frac{1}{4}$ mile east of B. M. 1029 near Irwin.
10. Redstone clay, outcrop at Cowansburg Station just west of southwest corner of quadrangle.
11. Redstone clay, outcrop 100 yards east of the east end of Radebaugh tunnel, Pennsylvania Railroad main line.
12. Redstone clay, outcrop at B. M. 1214, $1\frac{1}{4}$ miles north-northwest of Delmont, Salem township.
13. Redstone clay, outcrop $\frac{1}{2}$ mile northeast of Pleasant Valley, Penn township.
14. Redstone clay, outcrop $\frac{1}{2}$ mile north of station at Irwin.
15. Redstone clay, outcrop $\frac{3}{4}$ mile northwest of station at Irwin.
16. Redstone clay, first cut east of station at Irwin.
17. Redstone clay, quarry of Keystone Clay Products Co., $\frac{1}{2}$ mile northeast of Huff, Hempfield township.
18. Redstone coal horizon, outcrop along Pennsylvania Railroad cut-off $\frac{1}{2}$ mile southwest of Carbon.
19. Redstone clay, outcrop $\frac{3}{4}$ mile north-northeast of Huff, Hempfield township.
20. Pittsburgh limestone horizon, outcrop in stream bank $\frac{1}{2}$ mile west of Irwin.
21. Clarksburg limestone horizon, outcrop 350 yards east of B. M. 1289 on the Lincoln Highway between Adamsburg and Grapeville.
22. Clarksburg limestone horizon, railroad cut $\frac{1}{2}$ mile south-south-east of B. M. 1036 and $1\frac{3}{4}$ miles west-southwest of Sloan, Salem township.
23. Clarksburg limestone horizon, outcrop at B. M. 1316, Bell township.
24. Wellersburg clay, railroad cut $\frac{1}{2}$ mile northwest of Larimer, North Huntingdon township.
25. Duquesne clay, outcrop $\frac{3}{4}$ mile south of Mamont, Washington township.
26. Duquesne clay, railroad cut $\frac{1}{2}$ mile southeast of Ardara Station.

Fig. 23. Sections of clay beds.

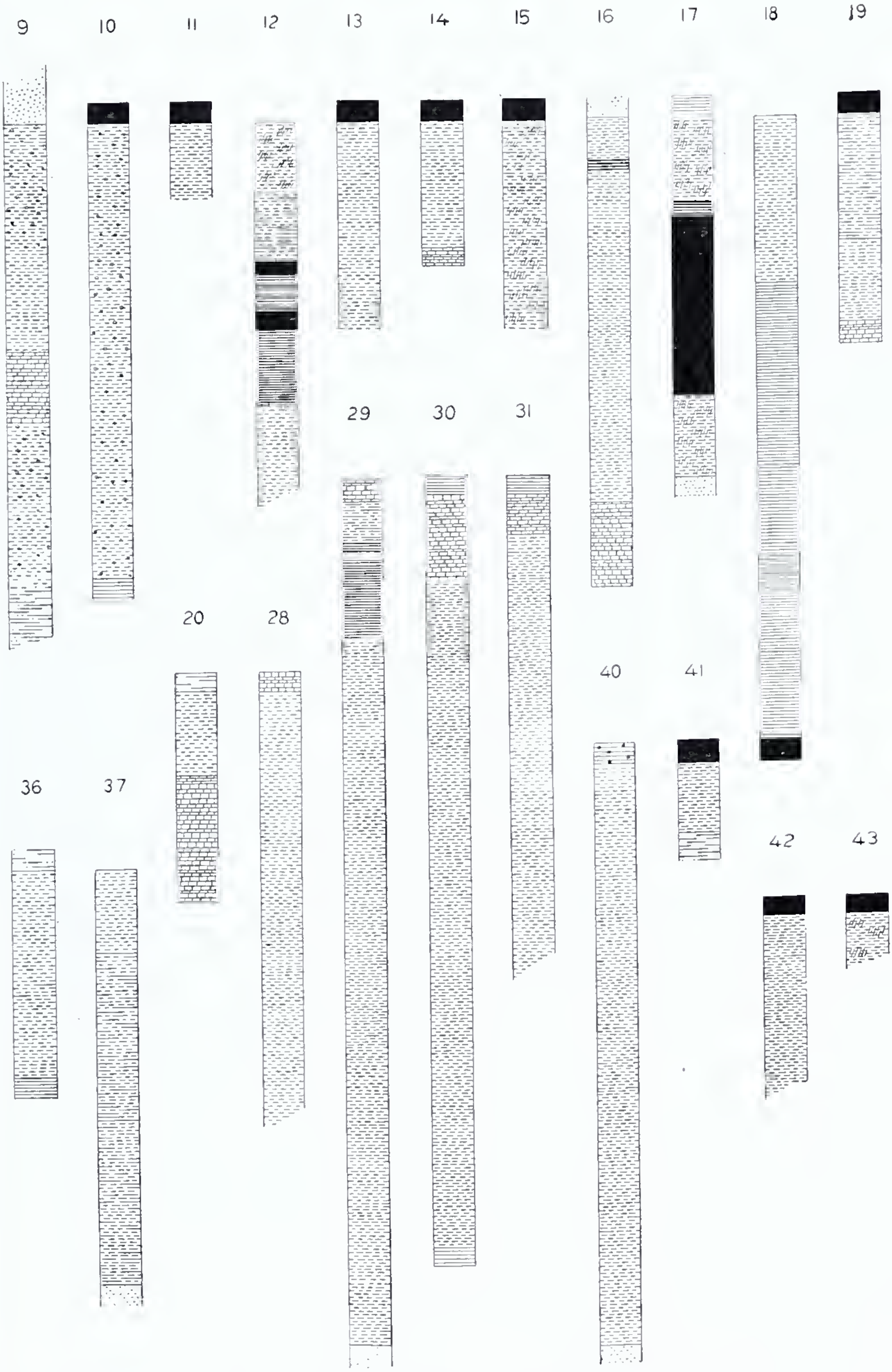


Fig. 23. Sections of clay beds, continued.

27. Duquesne clay, outcrop 1 mile east-northeast of Penn Station, Penn township.
28. Pittsburgh red beds, outcrop $\frac{3}{4}$ mile east-northeast of Blackburn, Penn township.
29. Pittsburgh red beds, Wynn and Starr quarry $\frac{1}{2}$ mile north of Blackburn, Penn township.
30. Pittsburgh red beds, railroad cut 400 yards southeast of Ardara Station, North Huntingdon township.
31. Pittsburgh red beds, railroad cut $\frac{3}{4}$ mile west of the station at Jeannette and about the same distance east of Penn Station.
32. Saltsburg horizon, outcrop $1\frac{3}{4}$ miles east of Boquet, Penn township.
33. Saltsburg horizon, outcrop 300 yards west of B. M. 1017 in the valley of Pucketa Creek, Franklin and Washington townships.
34. Saltsburg horizon, outcrop $1\frac{1}{4}$ miles east-southeast of Claridge, Penn township.
35. Saltsburg horizon, outcrop $1\frac{1}{2}$ miles west of Wiester, Washington township.
36. Woods Run horizon, outcrop $\frac{1}{2}$ mile north of Ardara Station, North Huntingdon township.
37. Pine Creek horizon, outcrop 2 miles northeast of Blackburn, Penn township.
38. Brush Creek coal horizon, outcrop $1\frac{1}{2}$ miles southwest of Murrysville, Franklin township.
39. Brush Creek coal horizon, railroad cut just east of station at Jeannette.
40. Mahoning coal horizon (?), railroad cut just east of station at Jeannette.
41. Mahoning coal horizon, outcrop $2\frac{3}{4}$ miles north of Radebaugh, Hempfield township.
42. Upper Freeport clay, outcrop in bank of Haymakers Run 2 miles northeast of Murrysville, Franklin township.
43. Upper Freeport clay, outcrop in stream bank, Oakford Park, 1 mile east of Jeannette.

LIMESTONE.*

Of the many limestone beds that outcrop within the quadrangle, eight are considered to have some economic importance. In descending stratigraphic order these are: Colvin Run, Mount Morris, Benwood, Fishpot, Redstone, Lower Pittsburgh, Clarksburg, and Ames. Of these by far the most important is the Benwood limestone which in places is thicker than all the rest put together. All the limestones thin out towards the north.

Colvin Run limestone.—The Colvin Run limestone occurs only in the tops of some of the higher hills in the trough of the Irwin syncline. It has been quarried for many years by the farmers on whose properties it occurs and when burnt is highly regarded as a soil sweetener. It has also been used to a small extent for road metal. A sample of the limestone was obtained from a quarry a third of a mile south of B. M. 1033 on the Lincoln Highway (Philadelphia and Pittsburgh pike). The sample included a proportionate part of each bed of limestone, the section including 4 feet of yellow, weathered limestone and 27 inches of fresh, gray limestone. The analysis shows the Colvin Run is a dolomitic limestone and hence would be unsuitable for fluxing purposes or for manufacturing cement.

*For detailed descriptions of limestones, see chapter on STRATRIGRAPHY.

FIGURE 24. Outcrop of Benwood limestone, showing upper and lower boundaries.

Analysis of Colvin Run limestone.

(Pittsburgh Testing Laboratory, analyst)

After drying at 150°C.:

Silica	8.40
Alumina	1.72
Iron oxide	3.00
Titanium oxide	Trace
Calcium carbonate	74.53
Magnesium carbonate	9.76
Loss on ignition (other than carbon dioxide)	.70
Alkalies and undetermined	1.89

Mount Morris limestone. Many years ago the Mount Morris limestone was quarried and burned at a point three-fourths of a mile south of Westmoreland City, North Huntingdon township. Six feet of limestone is exposed in the old quarry. The same limestone is well exposed along the new concrete road which passes through Chambers, North Huntingdon township. Near the top of the first hill northwest of Chambers a sample was cut from the limestone, the analysis of which follows.

Analysis of Mount Morris limestone.

(Pittsburgh Testing Laboratory, analyst)

After drying at 105°C.:

Silica	10.12
Alumina	1.63
Iron oxide	3.29
Titanium oxide	.20
Calcium carbonate	74.97
Magnesium carbonate	7.13
Loss on ignition (other than carbon dioxide)	2.07
Alkalies and undertermined	.59

Benwood limestone. The Benwood limestone outcrops in a large area (see Fig. 24) and has been used as a source of road metal and lime wherever it occurs. The beds vary greatly in composition and character but as a rule are sufficiently pure to make satisfactory lime when burned. Although kilns are sometimes used, the usual procedure in burning is to level off a spot about ten by fifteen feet and then build a pyramidal pile of alternate layers of coal and limestone. Wood is put at the bottom in order to ignite the mass. Once ignited, the pile is allowed to burn itself out and the material is then scattered over the fields. Naturally the resultant lime is far from pure and in many cases the larger chunks of limestone are only partly calcined. The farmers claim however, that

the results obtained when the lime is used on their fields, are equally as good as when pure, kiln-burnt lime is used. The claim is unsubstantiated.

Analyses of the Benwood limestone would seem to indicate that some of the limestone beds are more desirable from a utilitarian point of view than others, the value of the limestone depending largely on the percentage of magnesium carbonate present (i. e. the value varies inversely with that percentage). The first of the following analyses was made from a sample taken in the railroad cut a quarter of a mile east of the Irwin station. The sample included all of the limestone beds in the basal 20 feet of the Benwood. The second analysis was made from a sample taken half a mile north of Herminie which included only the top three feet of limestone there exposed. The beds sampled were weathered to a light-buff color and were also rather soft. They were chosen in order to test a theory formed during the progress of several seasons' field work—the theory being that the proportion of magnesium carbonate in a limestone is indicated by the manner in which the limestone weathers. In general it seems true that pure limestones are brittle and just as hard where exposed to weathering as where they are covered by hundreds of feet of rock and soil. Also, the weathered surface of a pure limestone is usually a lighter shade of the same color as the fresh rock. A dolomitic limestone, however, will weather to a yellow or light-buff color and the outside inch or so of the limestone will be comparatively soft. Whereas the pointed end of a geologic hammer will rebound sharply from the weathered surface of a pure limestone if it be struck, the hammer will rebound dully or perhaps not at all from the weathered surface of a dolomitic limestone. The amount of softening is, generally speaking, proportional to the percentage of magnesium carbonate in the rock (assuming approximately the same exposure to weathering agencies).

Analyses of Benwood limestone.

(Pittsburgh Testing Laboratory, analyst)

After drying at 105°C.:

	1	2
Silica	6.40	15.88
Alumina	1.01	3.77
Iron oxide	1.43	2.57
Titanium oxide	Trace	.30
Calcium carbonate	85.78	54.65
Magnesium carbonate	2.34	21.38
Loss on ignition (other than carbon dioxide)	?	1.00
Alkalies and undetermined	1.21	.45

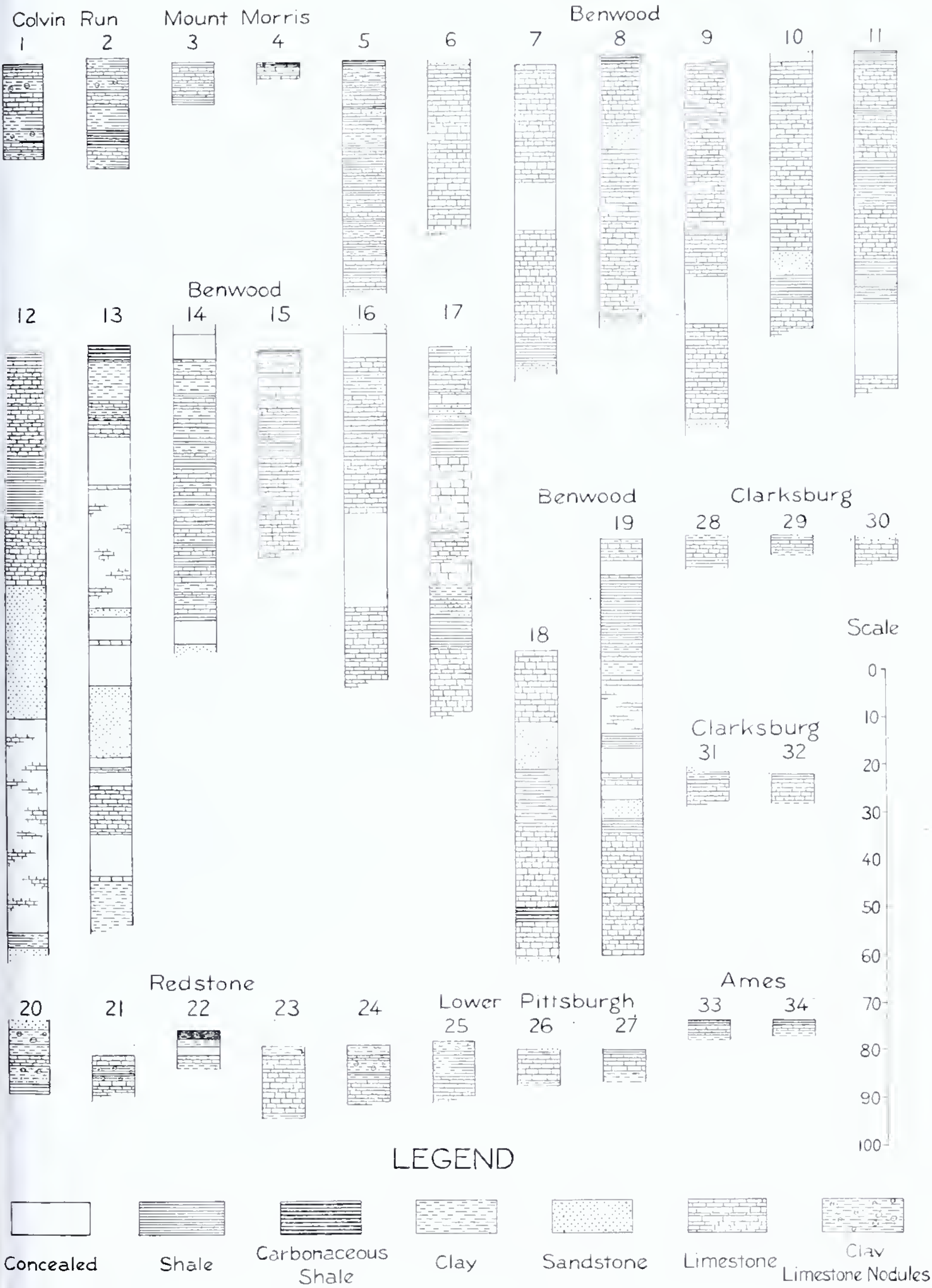


Fig. 25. Sections of limestone beds. Numbers refer to locations shown in figure 22.

There are many good quarry sites available in the area in which the Benwood limestone outcrops, but due to the greater percentage of limestone in the member in the southern half of the quadrangle, quarry operations for other than very local use, would probably be more profitable there. Probably the best location for a limestone quarry in the entire quadrangle is the hill just east of the junction of the Southwest Division and the Pittsburgh Division of the Pennsylvania Railroad.

Fishpot limestone. The Fishpot limestone is of importance only in the vicinity of Carbon, Hempfield township. In order to determine its qualities, a sample was taken where the limestone is exposed in the cut of the Pennsylvania Railroad cut-off at the south edge of the village. The limestone beds sampled totalled nine feet thick.

Analysis of Fishpot limestone.

(Pittsburgh Testing Laboratory, analyst)

After drying at 105°C.:	
Silica	9.04
Alumina	2.85
Iron oxide	2.15
Titanium oxide	.20
Calcium carbonate	72.81
Magnesium carbonate	8.67
Loss on ignition (other than carbon dioxide)	2.26
Alkalies and undetermined	2.02

Redstone limestone. Of little importance in the western and northern parts of the quadrangle, the Redstone limestone becomes of increasing importance towards the southeast. There it is quarried at several points for use as road metal and as a source of lime. Where it is thick and where the Redstone coal is thin or wanting, the Redstone limestone is hard and compact and usually quite pure. Although not known to have been quarried in this quadrangle for such a purpose, farther south it has been used largely for flux. Many available quarry sites are to be found along its extended outcrop in the Greensburg syncline.

Analyses of Redstone limestone.

(Pittsburgh Testing Laboratory, analyst)

After drying at 105°C.:	1	2
Silica	5.04	11.36
Alumina	1.77	2.57
Iron oxide	2.15	1.43
Titanium oxide	Trace	.20
Calcium carbonate	81.84	79.35
Magnesium carbonate	5.11	2.95
Loss on ignition (other than carbon dioxide)	.66	18
Alkalies and undetermined	3.43	1.96

Sample 1. Sample taken from a 28 inch limestone bed occurring 7 feet below the base of the Redstone coal at the quarry of the Keystone Clay Products Company, one fourth of a mile north of Huff, Hempfield township.

Sample 2. Sample taken from a 19 inch bed exposed in a cut of the Pennsylvania Railroad, 350 yards east of the Irwin station.

Lower Pittsburgh limestone. This limestone is best developed south of the main line of the Pennsylvania Railroad, although it also occurs in the northwestern part of the quadrangle. Occurring usually in several beds, the particular limestone bed referred to is the dense, thick bed occurring from 20 to 40 feet beneath the base of the Pittsburgh coal. In many places this bed is four feet thick and nearly everywhere it is over three feet thick in the area mentioned. It has been quarried quite extensively by the farmers in whose fields it outcrops and the lime obtained by burning it is regarded very highly.

At a point about three-fourths of a mile northwest of Arona on the W. A. Bussard farm, the limestone was mined by drift on a small scale. The bed at this point is 4½ to 5 feet thick and is immediately overlain by the Lower Pittsburgh sandstone.

Analyses of Lower Pittsburgh limestone.
(Pittsburgh Testing Laboratory, analyst)

After drying at 105°C.:	1	2
Silica	6.64	5.68
Alumina	1.64	1.68
Iron oxide	1.72	2.72
Titanium oxide	Trace	Trace
Calcium carbonate	82.76	81.31
Magnesium carbonate	4.64	5.65
Loss on ignition (other than carbon dioxide)	1.46	1.69
Alkalies and undetermined	1.14	1.27

Sample 1. Sample taken in a cut of the Hempfield Branch, Pennsylvania Railroad, three-fourths of a mile east-northeast of Pennine, Hempfield township. The limestone bed measured 54 inches thick, the bottom 6 inches being somewhat shaly.

Sample 2. Sample taken in a cut of the Pennsylvania Railroad a third of a mile west of Irwin. Limestone bed 55 inches thick.

Clarksburg limestone. Like the Lower Pittsburgh limestone just described, the Clarksburg limestone is best developed in the region southwest and south of Greensburg where it attains a maximum development of about five feet. In other parts of the quadrangle the the beds are thin and separated by beds of shale and clay five feet or more thick, so that quarrying the limestone is not feasible.

A sample was cut from the limestone beds exposed in an abandoned quarry one-half mile south of Fosterville, Hempfield township. The section exposed there is as follows:

Section half a mile south of Fosterville.

	Ft.	in.
Sandstone, Connellsville	11	
Shale, sandy	2	6
Clay, gray	1	6
Limestone, shaly, yellow		6
Limestone, compact	1	10
Limestone, shaly		3½
Limestone, compact	2	1½
Clay		

The analysis of the sample shows that it is suitable for road metal or for use as a soil sweetener.

Analysis of Clarksburg limestone

(Pittsburgh Testing Laboratory, analyst)

After drying at 105°C.:

Silica	8.04
Alumina	2.01
Iron oxide	1.43
Titanium oxide	Trace
Calcium carbonate	82.20
Magnesium carbonate	5.35
Loss on ignition (other than carbon dioxide)	1.01

Ames limestone. Although it has never been quarried anywhere on a large scale, the Ames limestone in years past was quarried at many points by the farmers on whose properties it occurred, particularly along the Grapeville anticline in the south part of the quadrangle. It was so well thought of as a soil conditioner that several feet of cover were sometimes moved in order to recover only one foot or less of limestone. The limestone was not burned, as a rule, but was spread directly on the fields. The results obtained were most beneficial, according to report. One reason it is no longer being quarried except at a few isolated points, is because most of the easily available limestone has already been removed.

Two samples of the Ames limestone were collected for analysis, one at a point three-fourths of a mile southeast of Fosterville, Hempfield township, and a second in a cut of the Pennsylvania Railroad a quarter of a mile southeast of Ardara, North Huntingdon township. Where the first sample was taken, the Ames occurs as a single bed,

10 inches thick. In the cut near Ardara, the Ames occurs as several beds of limestone of variable thickness, separated by thin and variable beds of limy, clay-shale. The total thickness of limestone and interbedded rock is 29 inches.

Analyses of Ames limestone.

(Pittsburgh Testing Laboratory, analyst)

After drying at 105°C.:	1	2
Silica	20.60	9.00
Alumina	8.98	1.99
Iron oxide	2.86	1.43
Titanium oxide	.40	.30
Calcium carbonate	58.97	79.44
Magnesium carbonate	4.11	4.02
Loss on ignition (other than carbon dioxide)	1.37	None
Alkalies and undetermined	2.71	3.82

Some idea of the relative thickness of the more important limestone horizons can be obtained from figure 25.

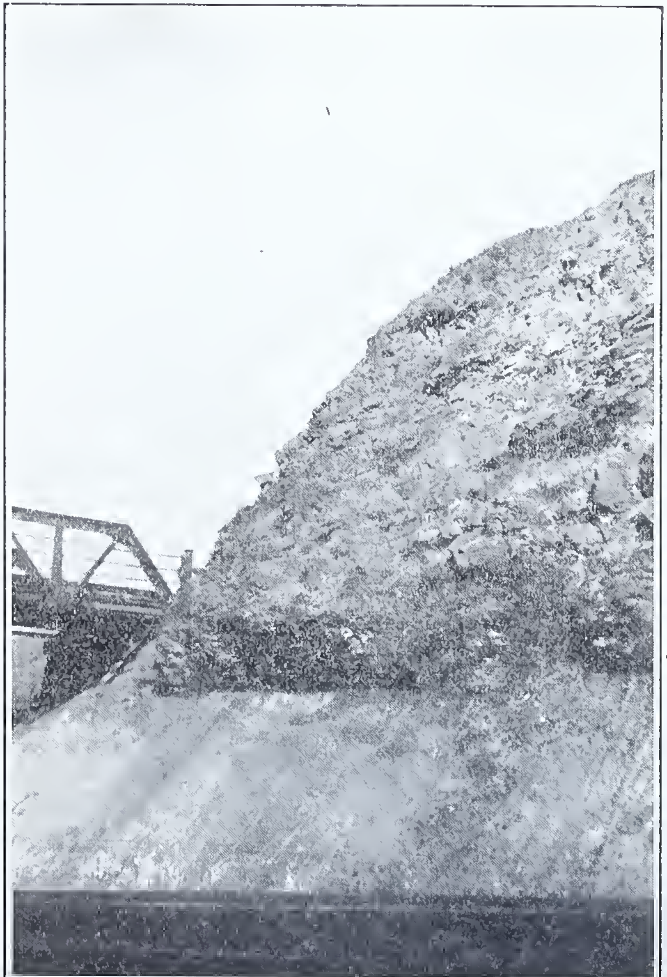
SANDSTONES.

The abundance of sandstone outcropping in the Greensburg quadrangle is indicated by the large number of sandstone quarries through out the entire quadrangle and most of which are shown on Plate XI. Every named sandstone bed occurring in the quadrangle has been quarried to some extent, although some have been worked more than others.

Where massive the sandstones are all very much alike. They are all arkosic, cross-bedded, and of about the same color. In the chapter on Stratigraphy detailed descriptions are given of the minor differences by which it is usually possible to distinguish them. The following list enumerates the sandstones in the order of their importance: Saltsburg, Morgantown, Mahoning, Waynesburg, Sewickley, Connellsville, Upper Pittsburgh, Buffalo, "Bench" (in Benwood member), Uniontown, Lower Pittsburgh, Grafton (Birmingham shale), and Washington.

Of the considerable quantity of sandstone that has been quarried to date, but little has been used as dressed stone in buildings. This is due to the cross-bedding of the sandstone and the fact that individual beds are seldom over three feet thick. Since a smooth, even texture is essential in a building stone it is evident that the aforementioned characteristics preclude the possibility of the sandstones listed ever attaining a wide use in such work.

PLATE XIII



A. Morgantown sandstone one mile southeast of Adera station, north Huntingdon town-

B. Saltsburg sandstone and Buffalo sandstone in big cut east of Donohoe, Latrobe quad-

Most of the sandstone quarried has been used in rough foundation work, for retaining walls, and as road metal. Small quantities have been used for flagstones and other purposes.

WATER RESOURCES.

Surface water. As previously mentioned in the description of the topography, there are no large streams within or even touching the quadrangle. This condition is due, not to a lack of precipitation, but to the fact that the Greensburg quadrangle is on the divide between the Conemaugh and Youghiogheny rivers. Many small streams, combining into a few good-sized creeks, serve to drain the whole quadrangle. The multitude of tiny streams and the many springs that go to make them, provide water within easy reach of everyone. Ground water is usually only a few feet below the surface and those farmers not fortunate enough to have a spring on their property can usually obtain all the water they need by sinking shallow wells. A few farmers have built cisterns near their homes to catch the rain-water from the roofs, and a few others have installed windmills for pumping water. The majority of them, however, obtain their water either from springs or shallow wells.

Underground water. Coal beds, clay beds, limestone beds and even occasionally a compact sandstone, all serve as barriers to the downward flow of surface waters and direct it to the surface in numerous springs. The Pittsburgh coal and the clay beneath it are particularly good water carriers. In fact, the crop of the Pittsburgh coal is sometimes easily traced by the springs and seepages along it.

Rocks below these that outcrop are frequently water-bearing. Thus, in the synclines and down the pitch of the anticlines, water is frequently found in the sands above the Thirty foot sand. The Thirty foot and the sands below are usually dry.

Water in the shallower sands is usually fresh, and that in the Murrysville and Hundred-foot sands frequently is a fairly strong brine. In the southern part of the quadrangle several wells were sunk to the Big Injun and Murrysville sands by the Pittsburgh Salt and Chemical Company (now the Hempfield Gas & Oil Company) and the brine obtained was used in manufacturing salt. The supply of brine failed however and these operations ceased years ago.

Water supply of principal towns. The three principal towns in the quadrangle are supplied with water by the Westmoreland Water Company. This company obtains its water from reservoirs near the sources of five of the smaller streams in or near the quadrangle. The main reservoir of the company, the Immel reservoir, has a cap-

acity of 177,000,000 gallons and is located on the headwaters of Nine Mile Run, five miles south of Latrobe and nine miles southeast of Greensburg. Smaller reservoirs are located in and near the three towns.

Average daily consumption, in gallons.

District	1920	1921	1922
Greensburg, Youngstown and vicinity	1,460,000	1,550,000	1,520,000
Jeannette, Penn, Manor, Westmoreland City	680,000	768,000	782,000
Irwin and vicinity	194,000	207,000	178,000
	2,334,000	2,525,000	2,480,000

The Consumers Water Company and the North Irwin Water Company furnish water to Westmoreland City and part of the town of Irwin respectively. The source of supply of the former is a small tributary of Brush Creek, between Irwin and Westmoreland City. That of the latter is Tinker Run, which empties into Brush Creek at Irwin.

Water power. The small size of the streams and their moderate rate of fall prevent commercial water-power development. Several streams have enough volume and fall, however, to furnish power for a small saw-mill or perhaps a grist-mill, and at many more places it would seem that enough water power could be developed to run a dynamo for electric service on one farm. As yet no attempt has been made to utilize this source of power.

Climatological table. The following table[13] indicates the moderate and delightful climate enjoyed by the residents of this region.

[13] U. S. Weather Bureau, Climatological data for the United States, by Sections; Vol. XXV, No. 13, p. 50, 98, Annual Summary, 1921.

Climatological data for the years 1920 and 1921.

		Station			
		Greensburg		Irwin	
		1921	1920	1921	1920
Temperature (deg. F.)	Elevation feet	1150	1150	884	884
	Length of record, years	4	3	22	21
	Annual mean	51.6	50.3	----	----
	Highest	94.	89.	94.	----
	Date	July 5	May 31	July 4	----
	Lowest	2	-2	1	-2
	Date	Feb. 21	Jan. 4	Feb. 21	Jan. 5
Precipitation (inches)	Length of record, years	14	13	25	24
	Total for the year	49.13	40.97	44.67	35.30
	Greatest monthly	6.80	6.95	7.52	6.36
	Month	Nov.	June	June	June
	Least monthly	2.42	1.60	2.05	1.14
	Month	May	Oct.	Feb.	May
	Total snowfall (unmelted)	34.5	44.1	----	----
Sky	Number clear days	144	131	----	151
	Number partly cloudy days	90	108	----	102
	Number cloudy days	131	127	----	113
	Prevailing direction of wind	SW	SW	----	----

APPENDIX

Some typical drill-hole records are here given in detail in the hope that they may be of some use to companies and individuals drilling in this quadrangle. The exact location of each well listed is shown on Plate XII. Most of the wells listed start below the horizon of the Pittsburgh coal bed and in such cases the interval between the two is given in the record as: To Pittsburgh coal...... (so many) feet.

For the benefit of those unused to drillers' terms, some of those used most frequently are defined.

Sand—sandstone. Slate—shale. Lime—limestone.

Shells — thin hard strata usually sandstone beds, separated by softer material.

Red rock — refers to the color of the drillings brought up by the sand pump and may be either sandstone or shale.

(1) C. K. Cooper farm, Philadelphia Co. well No. 475. Patton township, Allegheny County. Well completed May 23, 1919.

To Pittsburgh coal ....90 feet.

	From (Feet)	To (Feet)
Slate	0	476
Sand	476	500
Slate	500	615
Sand white	615	665
Slate	665	680
Mud scum, black	680	700
Slate	700	705
Coal, Middle Kittanning	705	710

	From (Feet)	To (Feet)
Slate, white	710	840
Sand, white, hard	840	920
Slate and shells	920	960
Sand, hard	960	1000
Slate and shells	1000	1080
Sand, hard	1080	1500
Slate and shells, black	1500	1540
" " " red, Patton	1540	1580
" " "	1580	1715
Sand, hard, Berea	1715	1770
Slate, soft	1770	1816
Sand, white, soft, Murrysville	1816	1930
Slate, black, soft	1930	1950
Slate, hard, Hundred-foot	1950	2036
Slate and shells, white	2036	2130
Red rock	2130	2310
Sand, hard, red, Fourth	2310	2340
Slate and shales	2340	2385
Sand, Fifth	2385	2415
Slate	2415	2450
Sand, Sixth (gas at 2453)	2450	2466
Slate	2466	2483

(2) Elizabeth Smellacer farm, T. W. Phillips Gas Co., Plum township, Allegheny County. Well completed Nov. 11, 1916.

To Pittsburgh coal .200 feet.		
Coal, Lower Kittanning (?)	680	686
Sand, white	745	845
" white, Seventy-foot	989	1100
" Big Injun	1115	1265
" Squaw	1350	1500
" Berea	1590	1625
" white, Murrysville (water at 1695)	1692	1800
" " Hundred-foot (gas at 1850, water at 1914)	1815	1968
" red, Boulder	2060	2075
" " Third	2115	2120
" " Fourth	2211	2217
" " "	2235	2239
" brown, Fifth	2296	2309
" " Sixth (some gas at 2350)	2347	2371
Sand	2550	2625
" white	2915	2955
" brown, Speechley Stray	3040	3050
" " Speechley	3121	3139
" red, Sheffield	3388	3419
" white, Bradford (?)	3615	3684
Total depth		3684

(3) G. M. Greer farm, Peoples Natural Gas Co., well No. 1295, Patton township, Allegheny County. Well completed June 6. 1917.

To Pittsburgh coal .320 feet.		
Coal, Lower Bakerstown	110	115
" Middle Kittanning	480	487
Sand	720	780
"	805	845
"	870	950
" Murrysville	1583	1703
" Hundred-foot (gas at 1811)	1710	1842
Sand, Thirty-foot	1845	1900
" Boulder	1940	1965
" Third	1995	2025
" Fourth	2095	2131
" Fifth	2180	2200
" Sixth	2260	2270
" Elizabeth	2290	2302
" Speechley Stray	2925	2950
" Speechley	2980	3004
Sand	3425	3495
" Bradford	3530	3590
Slate	3590	3677

(4) S. C. Alter farm, well No. 1, T. W. Phillips Gas and Oil Co., Plum township, Allegheny County. Well completed in February 1913.

	From (Feet)	To (Feet)
To Pittsburgh coal ....95 feet.		
Coal, Upper Freeport	550	558
" Lower Kittanning	770	776
Limestone, Vanport	815	824
Sand, Murrysville	1782	......
" Hundred-foot (oil at 1921)	1912	2010
" Boulder (?)	2175	2190
" Third	2240	2320
" Fifth (gas at 2362)	2350	2390
" Sixth	2430	2450
Deepened in Nov., 1921.		
Sand, First Warren	2710	2722
" Second Warren	2795	2807
" Speechley Stray	3142	3148
" Speechley	3182	3202
" Tiona	3300	3311
" Sheffield	3440	3454
"	3615	3630
"	3724	3745
" First Bradford	3776	3791
Total depth		3806

(5) James Yeager farm, well No. 2, T. W. Phillips Gas and Oil Co., Plum township, Allegheny County. Well completed May 24, 1913.

To Pittsburgh coal ....20 feet.		
Coal, Upper Freeport	630	638
"	860	870
Sand, Hundred-foot	2000	2100
" Thirty-foot	2115	2150
" Boulder	2175	2200
" Third	2250	2300
" Fourth	2340	2390
" Fifth (gas at 2475)	2420	2490
" Sixth	2530	2560
Sand	2825	2850
" Speechley Stray	3206	3221
" Speechley	3300	3349
Total depth		3349

(6) Rebecca J. Ludwick farm, well No. 3, American Natural Gas Co., Washington township, Westmoreland County. Well completed February 8, 1921.

To Pittsburgh coal ....290 feet.		
Soil	0	8
Clay, red	8	38
Slate and shells	38	88
Sand	88	105
Slate and shells	105	155
Sand	155	170
Slate	170	180
Sand (water at 195)	180	205
Slate and shells	205	255
Sand	255	275
Slate	275	350
Red rock	350	392
Slate and shells	392	457
Sand	457	477
Slate	477	532
Sand	532	555
Coal, Lower Kittanning	555	559
Slate	559	590
Limestone	590	600
Slate and shells	600	650
Sand	650	680

	From (Feet)	To (Feet)
Slate, black	680	720
Sand	720	805
Slate, black	805	850
Sand, Sixty-foot	850	890
Sand, Seventy-foot	890	960
" Big Injun	960	1,350
Slate and shell	1350	1375
Sand	1375	1395
Slate	1395	1410
Slate and shell	1410	1600
Sand, Murrysville	1600	1740
" Hundred-foot	1740	1840
Slate	1840	1850
Sand, Thirty-foot	1850	1870
Red rock	1870	2180
Sand, Fifth	2180	2220
Slate	2220	2290
Sand, Sixth	2290	2300
Slate and shells	2300	2932
Sand, Speechley Stray (gas)	2932	2955
Slate	2955	2984

(7) R. G. Sharp farm, well No. 3, Philadelphia Co., well No. 640, Plum township, Allegheny County. Well completed May 13, 1918.

To Pittsburgh coal ....45 feet.		
Clay, yellow, soft	0	12
Lime, white, hard	12	15
Red rock	15	25
Mud	25	75
Red rock	75	95
Slate, dark, soft	95	145
Lime, white, hard	145	150
Red rock	150	200
Slate	200	300
Lime	300	350
Slate, white, soft	350	500
Lime, white, hard	500	510
Slate, dark, soft	510	600
Coal, blocky, Upper Freeport	600	608
Slate, white, soft	608	640
Sand, white, hard	640	700
Slate and shells	700	900
Sand, white	900	980
Slate, dark soft	980	1000
Lime, dark	1000	1100
Sand, white, hard	1100	1145
Slate, dark, soft	1145	1150
Sand, yellow, hard, Big Injun	1150	1480
Slate and shells	1480	1790
Sand, white, hard, Berea	1790	1810
Slate, white soft	1810	1850
Sand, white, soft, Murrysville	1850	1960
Slate, white	1960	1980
Sand, white, hard, Hundred-foot	1980	2000
Sand, red, Hundred-foot	2000	2020
Sand, white, Hundred-foot	2020	2050
Slate	2050	2110
Red rock	2110	2290
Sand, white, hard, Third	2290	2310
Slate, white, soft	2310	2370
Sand, white, hard, Fourth	2370	2425
Slate, dark, soft	2425	2430
Sand, dark, hard, Fifth (gas)	2430	2485
Slate and shells	2485	3070
Sand, gray, hard	3070	3080
Slate, soft	3080	3106
Shells, hard	3106	3111
Slate, dark	3111	3165
Sand, dark, hard, Speechley Stray (oil at 3107)	3165	3185
Slate, dark	3185	3193

(8) Levi Beamer farm, well No. 3, American Natural Gas Co., Franklin township, Westmoreland County. Well completed Nov. 11, 1920.

	From (Feet)	To (Feet)
To Pittsburgh coal ....415 feet.		
Mud	0	25
Slate	25	145
Coal, Brush Creek	145	148
Sand	148	370
Coal, Upper Kittanning	370	375
Limestone	375	420
Sand	420	480
Slate	480	535
Sand	535	600
Slate	600	670
Sand, Seventy-foot	675	850
Sand, Big Injun	850	1170
Slate and shells	1170	1515
Sand, Murrysville (little gas at 1595)	1515	1630
Sand, Hundred-foot (little gas at 1720)	1630	1730
Slate	1730	1780
Sand, Thirty-foot (gas at 1795)	1780	1810
Slate	1810	1840
Red rock	1840	2130
Sand, Fifth	2130	2150
Slate and shells (show of gas at 2180)	2150	2870
Sand, Speechley, (gas at 2880)	2870	2890

(9) W. A. Young farm, well No. 4, T. W. Phillips Gas and Oil Co., Franklin township, Westmoreland County. Well completed July 27, 1914.

To Pittsburgh coal ....145 feet.		
Coal, Middle Kittanning	668	672
" Lower Kittanning	722	727
Limestone, Vanport	740	760
Sand, Big Injun	995	1300
" Murrysville	1780	1890
" Hundred-foot	1890	2020
" Boulder	2095	2140
" Fourth	2215	2235
" Fifth (gas at 2377)	2330	2395
" Sixth	2414	2440
" Elizabeth (gas at 2465)	2462	2476
Total depth		3182

(10) Susan Irwin farm, Philadelphia Co. well No. 3090, Franklin township, Westmoreland County. Well completed March 30, 1915.

To Pittsburgh coal ....525 feet.		
Clay	0	10
Sand	10	70
Slate	70	260
Coal, Upper Kittanning	260	265
Slate	265	290
Sand	290	320
Slate and shell	320	420
Sand	420	530
Lime shells	530	580
Sand	580	638
Slate	638	650
Sand	650	675
Slate	675	690
Sand, Seventy-foot	690	800
" Big Injun	800	1125
Slate and shell	1125	1195
Sand	1195	1220
Slate and shell	1220	1305

	From (Feet)	To (Feet)
Sand, Berea (little gas at 1315)	1305	1370
Slate and shell	1370	1410
Sand, Murrysville (water at 1470)	1410	1525
Sand, Hundred-foot (show of oil)	1525	1662
Slate	1662	1670
Sand, Thirty-foot	1670	1705
Slate and shell	1705	2000
Sand, Fifth (gas)	2020	2056
" Sixth	2056	2070
Slate	2070	2101
Sand, Elizabeth (gas)	2101	2110
Slate	2110	2120

(11) J. I. Patterson farm, Peoples Natural Gas Co. well No. 1245, Franklin township, Westmoreland County. Well completed Mar. 1, 1917.

To Pittsburgh coal .365 feet.		
Coal, Upper Kittanning	425	......
Sand, Murrysville	1515	1630
" Hundred-foot	1660	1770
" Fifth	2150	2165
" Elizabeth	2275	2280
" Speechley	2900	2920
" Bradford	3515	3590
Slate	3590	3651

(12) Harvie Pedder farm, well No. 2, Philadelphia Co. well No. 3071, Penn township, Westmoreland County. Well completed Mar. 13, 1914.

To Pittsburgh coal .390 feet.		
Clay	0	16
Slate and shale	16	140
Coal, Brush Creek	140	144
Slate	144	285
Sand	285	300
Slate	300	400
Coal, Middle Kittanning	400	406
Slate	406	440
Sand	440	510
Slate	510	550
Sand	550	600
Slate	600	610
Sand, Seventy-foot	610	750
Slate	750	780
Sand, Big Injun	780	960
Slate and shell	960	1015
Sand	1015	1100
Slate	1100	1200
Sand (water)	1200	1280
Slate	1280	1405
Sand, Berea	1405	1440
Slate	1440	1515
Sand, Murrysville	1515	1619
Slate	1619	1620
Sand, Hundred-foot and Thirty-foot	1620	1785
Slate	1785	1870
Red rock	1870	2025
Sand, Fourth	2025	2040
Slate	2040	2096
Sand, Fifth	2096	2121
Slate	2121	2175
Sand, Sixth	2175	2242
Slate	2242	2275

(13) J. S. Glendenning farm, Peoples Natural Gas Co. well No. 1272, Penn township, Westmoreland County. Well completed May 2, 1917.

To Pittsburgh coal .85 feet.		
Slate	0	240
Lime shells	240	250

	From (Feet)	To (Feet)
Coal, Upper Bakerstown (?)	250	255
Slate and shells	255	720
Coal, Middle Kittanning	720	726
Slate and shells	726	758
Coal, Lower Kittanning	758	760
Sand	830	905
Slate	905	908
Sand	908	925
Slate	925	980
Sand, Big Injun	980	1205
Slate and shells	1205	1300
Sand	1300	1390
Slate and shells	1390	1485
Lime	1485	1575
Slate	1575	1580
Sand	1580	1605
Slate	1605	1610
Sand	1610	1645
Slate	1645	1700
Sand	1700	1750
Slate	1750	1775
" and shells	1775	1824
Sand, Murrysville	1824	1906
Slate	1906	1908
Sand, Hundred-foot and Thirty-foot	1908	2130
Lime shells	2130	2180
Slate	2180	2200
Red rock	2200	2300
Lime shells	2350	2370
Red rock	2370	2385
Sand, Fifth (show of gas at 2390)	2385	2400
Slate	2400	2493
Sand, Sixth (show of gas at 2495)	2493	2517
Slate and shells	2517	2862
Sand	2862	2882
Slate and shells	2882	3020
Sand	3020	3040
Slate and shells	3040	3130
Sand, Speechley Stray	3130	3150
Slate	3150	3228
Sand, Speechley	3228	3248
Slate and shells	3248	3515
Sand, Sheffield	3515	3550
Slate and shells	3550	3755
Sand, Bradford	3755	3790
Slate and shells	3790	3850
Slate	3850	3921

(14) J. G. Foight farm, Greensboro Gas Co. well No. 491, Penn township, Westmoreland County. Well completed June 5, 1920.

Conductor	0	14
Slate	14	16
Lime } Benwood	16	26
Sand, black } Benwood	26	78
Lime } Benwood	78	85
Shells and slate	85	140
Slate	140	150
Lime, Fishpot	150	160
Shells	160	220
Lime, Redstone	220	235
Slate and shells	235	266
Coal, Pittsburgh	266	273
Lime	273	278
Slate	278	375
Red rock	375	450
Slate and shell	450	575
Red rock	575	615
Slate	615	735
Sand, Buffalo	735	755
Slate	755	830
Sand, Mahoning	830	855
Slate	855	930

	From (Feet)	To (Feet)
Sand, Freeport (?)	930	960
Slate	960	1020
Sand	1020	1075
Slate	1075	1085
Coal, Middle Kittanning	1085	1088
Sand	1088	1135
Slate	1135	1215
Sand	1215	1310
Slate	1310	1335
Sand	1335	1355
Lime, Greenbrier	1355	1400
Slate and shells	1400	1480
Sand, Big Injun	1480	1775
Slate	1775	1810
Sand, Squaw	1810	1850
Slate	1850	1890
Sand, Papoose	1890	1930
Slate and shells	1930	1975
Sand	1975	2030
Slate	2030	2075
Sand, Berea	2075	2115
Slate	2115	2174
Sand, Murrysville	2174	2300
" Hundred-foot	2300	2400
Slate	2400	2410
Sand, Thirty-foot (gas)	2410	2450
Slate and shells	2450	2504
Red rock	2504	2750
Slate	2750	2785
Sand, Fifth	2785	2835
Slate	2835	2864
Sand, Sixth	2864	2895
Slate	2895	3040
Shells	3040	3460
"	3460	3500
Slate	3500	3605
Sand, Speechley	3605	3665
Slate	3665	3715
Shells	3715	3730
Slate	3730	3735
Sand, Tiona	3735	3760
Slate and shells	3760	3800
Slate	3800	3850
Shells	3850	3900
Slate	3900	3960
Shell	3960	4020
Slate	4020	4050
Shell	4050	4100
Slate	4100	4130
Sand, First Bradford	4130	4190
Slate	4190	4280
Sand, broken, Second Bradford (little gas at 4182)	4280	4295
Slate	4295	4365
Sand	4365	4385
Slate and shell	4385	4567
Sand, broken	4567	4577
Slate	4577	4694
Sand	4694	4714
Slate	4714	4802

Casing record:
57 ft. of 14 in.
300 " " 10 "
1344 " " $8\frac{1}{4}$ in.
2374 " " $6\frac{5}{8}$ "
2426 " " 3 " tubing

(15) Mary A. Snyder farm, well No. 1, T. W. Phillips Gas and Oil Co., Penn township, Westmoreland County. Well completed in October, 1915.

Coal, Pittsburgh	155	......
Coal, Brush Creek	715	......
Coal, Upper Kittanning	925	......

	From (Feet)	To (Feet)
Limestone	1000	......
Sand, Big Injun	1375	1500
" Murrysville	2070	2170
" Hundred-foot	2200	2320
" Sixth	2696	2712
" Speechley	3435	......
" Bradford	4080	......
Total depth		4116

(16) Hannah Smail farm, well No. 2, Philadelphia Co. well No. 3035, Penn township, Westmoreland County. Well completed Aug. 23, 1912.

To Pittsburgh coal ......415 feet.		
Clay	0	8
Slate	8	20
Sandstone	20	50
Slate, gray	50	250
Limestone	250	260
Coal	260	263
Slate	263	300
Sandstone	300	330
Slate	330	345
Sandstone	345	370
Coal	370	375
Slate	375	380
Sandstone	380	445
Coal	445	449
Slate	449	525
Sandstone	525	590
Slate	590	610
Sandstone	610	635
Slate	635	755
Sandstone, Seventy-foot and Big Injun	755	1085
Slate	1085	1205
Sandstone, Squaw	1205	1300
Slate	1300	1345
Sandstone, Berea	1345	1370
Slate	1370	1430
Sandstone, Murrysville	1430	1535
Slate	1535	1541
Sandstone, Hundred-foot	1541	1650
Slate	1650	1655
Sandstone, Thirty-foot	1655	1680
Slate	1680	1760
Red rock	1760	2015
Sandstone	2015	2027
Red rock	2027	2056
Sandstone, Fifth (gas)	2056	2081
Slate	2081	3426
Sandstone, Bradford (gas at 3438)	3426	3454
Slate	3454	3484

Casing record:

33 feet of 10 inch
803 " " 8 "
1753 " " $6\frac{5}{8}$ "
2130 " " 3 " tubing

(17) Gottlieb Kim farm, well No. 1, Westmoreland Gas Co., North Huntingdon township, Westmoreland County. Well completed May 14, 1917.

To Pittsburgh coal ......40 feet.		
Coal, Lower Bakerstown	398	400
Sand	705	837
"	890	975
Lime, Greenbrier	1160	1220
Sand, Big Injun, Squaw, Papoose	1220	1790

	From (Feet)	To (Feet)
Sand, Murrysville	1872	1965
" Hundred-foot	1975	2075
" Thirty-foot	2080	2120
Red rock	2160	2420
Sand, Fifth	2427	2441
" Sixth (show of gas)	2537	2568
" gray, Speechley	3287	3346
" Sheffield (small flow of gas)	3569	3577
" Bradford	3830	3838
Slate	3838	3928

Casing record:
837 feet of 8 in.
1972 " " 6½ "

(18) H. C. Frick Coke Co. property, Carnegie Gas Co. well No. 61, North Huntingdon township, Westmoreland County. Well completed August 17, 1918.

To Pittsburgh coal ....300 feet.

Coal, Upper Freeport	340	344
Sand	740	850
Lime, Greenbrier	850	915
Sand, Big Injun	915	1370
Slate and shale	1370	1585
Sand, Murrysville	1585	1710
" Hundred-foot	1710	1822
" Thirty-foot	1870	1885
" Sixth (small flow of gas)	2257	2277
Total depth		2367

(19) Jeannette Land Co. property, Peoples Natural Gas Co. well No. 1270, Sewickley township, Westmoreland County. Well completed July 20, 1918.

Clay	0	50
Lime, Benwood	50	150
Slate	150	160
Lime, Benwood	160	260
Slate	260	270
Lime	270	300
Slate	300	372
Coal, Pittsburgh	372	379
Slate	379	495
Slate and shell	495	830
Sand, Buffalo	830	900
Slate	900	1015
Coal, Upper Freeport	1015	1021
Lime	1021	1037
Slate	1037	1060
Unrecorded	1060	1100
Sand	1100	1130
Coal, Upper Kittanning	1130	1132
Slate	1132	1166
Coal, Middle Kittanning	1166	1171
Sand	1171	1181
Slate and shell	1181	1226
Sand	1226	1290
Slate	1290	1296
Sand	1296	1380
Coal	1380	1383
Slate	1383	1540
Sand, Seventy-foot	1540	1700
Sand, Big Injun	1702	2065
Sand	2067	2100
Sand, Berea	2130	2165
Sand, Murrysville (water at 2268)	2248	2330
Slate	2330	2340
Sand, Hundred-foot	2340	2450
Sand, Thirty-foot	2460	2520

	From (Feet)	To (Feet)
Sand, Fifth	2825	2842
" Sixth	2900	2935
" Speechley	3655	3710
" Bradford	4220	4230
Slate	4230	4370

(20) John Mitchell farm, Carnegie Gas Co. well No. 50, Sewickley township, Westmoreland County. Well completed Nov. 24, 1916.

Conductor	0	8
Coal, Redstone	372	375
" Pittsburgh	417	427
Sand	910	975
"	1010	1060
"	1130	1190
"	1215	1300
"	1310	1415
"	1460	1500
Lime, Little Lime	1500	1512
Shale, pencil cave } Greenbrier	1512	1520
Lime, Big Lime	1540	1560
Sand, Big Injun	1660	2130
" Murrysville	2285	2390
" Hundred-foot	2435	2532
Slate and shells	2532	3735
Sand, Speechley	3735	3770
Slate and shells	3770	4453

Casing record:
455 feet of 10 inch
1465 " " $8\frac{1}{4}$ "
2406 " " $6\frac{5}{8}$ "

(21) Blackburn farm, well No. 4, Fayette County Gas Co., Hempfield township, Westmoreland County. Well completed May 20, 1921.

To Pittsburgh coal ....290 feet.

Clay	0	8
Slate and shells (water at 90)	8	175
Sand	175	193
Slate and shells	193	275
Sand (water at 305)	275	305
Coal, Brush Creek	305	310
Slate and shells	310	395
Sand	395	460
Slate	460	470
Coal, Upper Kittanning (water)	470	473
Slate and shells	473	500
Sand	500	530
Slate and shells	530	542
Coal, Middle Kittanning	542	545
Sand	545	585
Slate	585	600
Sand	600	648
Lime	648	685
Slate	685	700
Sand	700	785
Slate, lime and shells	785	830
Lime, Greenbrier	830	870
Red rock	870	875
Sand, Seventy-foot (gas at 945)	875	1012
Slate, pencil cave (?)	1012	1014
Lime	1014	1020
Sand, Big Injun	1020	1133
Slate	1133	1158
Sand, Squaw	1158	1170
Slate and shells	1170	1300
Sand, Papoose	1300	1315
Slate	1315	1325
Sand	1325	1360
Slate and lime shells	1360	1530
Sand, Berea and Murrysville (water at 1535)	1530	1690

	From (Feet)	To (Feet)
Slate	1690	1692
Sand, Hundred-foot (gas at 1716)	1692	1724
Slate	1724	1725
Sand, Hundred-foot	1725	1750
Slate and sand shells	1750	1825
Red rock, slate and lime shells	1825	2086
Sand, Fourth	2086	2100
Red rock	2100	2135
Sand, Fifth	2135	2152
Slate	2152	2215
Lime, gritty	2215	2230
Slate and lime shells	2230	2867
Sand, Speechley Stray (gas at 2868)	2867	2878
Slate and lime shells	2878	2955
Unrecorded	2955	3060
Sand, Tiona (?) (gas at 3065)	3060	3066

Casing record:
232 feet of 10 inch
920 " " $8\frac{1}{4}$ "
1633 " " $6\frac{5}{8}$ "

(22) C. H. Roose farm, American Natural Gas Co., Hempfield township, Westmoreland County. Well completed Jan. 1, 1918.

To Pittsburgh coal .....30 feet.		
Clay	0	90
Sand (water at 95)	90	105
Red rock	105	380
Slate	380	490
Sand	490	540
Slate	540	570
Lime	570	580
Slate	580	615
Sand	615	657
Coal, Upper Freeport	657	......
Slate	657	740
Coal, Lower Freeport	695	......
Sand	740	825
Slate	825	875
Sand	875	887
Coal, Clarion	887	891
Sand	891	955
"	955	995
Slate	995	1025
Sand	1025	1100
Slate	1100	1135
Red rock, Mauch Chunk	1135	1165
Slate	1165	1170
Sand, Big Injun (top, hard, white; bottom, dark)	1170	1520
Slate	1520	1595
Red rock, Patton	1595	1615
Slate	1615	1625
Sand, broken, Squaw	1625	1710
Slate	1710	1740
Sand	1740	1780
Slate	1780	1860
Sand, soft, white, Murrysville (water at 1875—filled hole 800 feet)	1860	1945
Slate	1945	1950
Sand, Hundred-foot (50 ft. of hard sand; bottom broken. Water at 1970)	1950	2050
Slate	2050	2080
Sand, hard, blue, Thirty-foot	2080	2105
Slate	2105	2170
Red rock	2170	2480
Slate	2480	3196
Sand, Speechley Stray (gas at $3216\frac{1}{2}$)	3196	3226
Slate	3226	3278
Sand, hard, gray, Speechley	3278	3308
Slate	3308	3525

Casing record:
385 feet of 10 inch
1240 " " 8 "
1950 " " $6\frac{5}{8}$ "
3184 " " 3 " tubing.

(23) Weitz farm (formerly M. J. Miller), well No. 1, American Window Glass Co., Hempfield township, Westmoreland County. Well completed December 30, 1915.

	From (Feet)	To (Feet)
To Pittsburgh coal .... 300 feet.		
Slate and red rock	0	250
Sand	250	320
Slate and shells	320	380
Sand	380	470
Slate	470	520
Sand	520	525
Coal, Middle Kittanning	525	531
Slate	531	580
Lime shells	580	665
Slate	665	745
Sand	745	790
Slate	790	840
Sand, Sixty-foot	840	875
Slate	875	900
Red rock, Mauch Chunk	900	906
Sand, Seventy-foot	906	1057
Slate	1057	1065
Sand, Big Injun	1065	1250
Slate and shells	1250	1300
Sand, Squaw	1300	1490
Slate	1490	1580
Sand, Murrysville	1580	1670
" Hundred-foot	1670	1770
" Thirty-foot	1770	1880
Red rock	1880	2135
Slate	2135	2186
Sand, Fifth	2186	2220
" Sixth (?)	2220	2240
Slate	2240	2290
Sand, Elizabeth	2290	2318
Slate and shells	2318	2954
Sand, Speechley (a little gas at 2974)	2954	2980
Slate and shells	2980	3181
Sand, Tiona (a little gas at 3185)	3181	3192
Slate and shells	3192	3755

Casing record:
840 feet of 8¼ inch
1910 " " 6⅝ "

(24) Donato Bondi property, well No. 2, American Window Glass Company. Hempfield township, Westmoreland County. Well completed March 10, 1916.

To Pittsburgh coal .... 390 feet		
Sand	260	280
Coal, Lower Freeport	332	336
Sand	375	405
"	585	615
Coal	619	624
Slate	624	630
Lime	630	650
Sand	650	685
Lime, Greenbrier	685	710
Sand, Seventy-foot	815	925
" Big Injun	925	1170
Murrysville	1480	1575
Slate	1575	1579
Sand, Hundred-foot	1579	1685
" Thirty-foot	1688	1758
Slate	1758	1780
Sand and shale	1780	1844
Red rock	1844	2080
Sand, Fifth	2100	2118
" Sixth	2142	2167

	From (Feet)	To (Feet)
Sand, Elizabeth	2202	2208
" Speechley Stray (gas at 2876)	2875	2893
" Speechley	2943	2983
" Tiona (gas at 3115 and 3125)	3103	3127
Total depth		3142

Casing record:
750 feet of $8\frac{1}{4}$ inch
1778 " " $6\frac{1}{2}$ "

(25) Adam Smith farm, Peoples Natural Gas Co. well No. 759, Hempfield township, Westmoreland County. Well completed Dec. 22, 1911.

To Pittsburgh coal .420 feet		
Slate	18	93
Sand, Buffalo	133	148
" Mahoning	225	300
" Freeport	315	365
"	385	435
" Gas	515	550
" Salt	600	660
Lime, Greenbrier	725	775
Sand, Big Injun	775	1205
"	1225	1275
" Berea	1350	1425
" Murrysville	1474	1574
" Hundred-foot	1574	1674
Slate	1674	1686
Sand, Thirty-foot	1686	1726
Slate and red rock	1726	2100
Sand, Fifth	2100	2150
Shells	2200	2225
"	2300	2600
"	2750	2840
Sand, Speechley (show of gas)	2878	2913
" Tiona	3060	3085
" Sheffield	3240	3270
Shells	3375	3506
Sand, Bradford	3516	3534
Slate	3534	3626

(26) The Kelly and Jones Co. property, Hempfield township, Westmoreland County. An old drill-hole.

Dirt	0	20
Slate	20	25
Coal, Pittsburgh	25	30
Limestone	30	85
Slate	85	140
Sand	140	160
Slate, red	160	180
Slate and shells	180	310
Sand	310	315
Slate and shells	315	360
Slate, red	360	375
Slate and shells	375	415
Sand	415	485
Slate	485	490
Limestone	490	525
Slate	525	540
Limestone	540	550
Slate and shells	550	620
Limestone (?)	620	705
Sand	705	750
Slate	750	765
Sand	765	815
Slate	815	840
Limestone, Middle Kittanning	840	860
Sand	860	890
Slate	890	910

	From (Feet)	To (Feet)
Sand	910	970
Slate	970	1065
Sand	1065	1150
Slate	1150	1155
Sand, Big Injun	1155	1565
Slate and shells	1565	1585
Sand, Squaw	1585	1635
Sand, red, Patton (?)	1635	1645
Slate	1645	1650
Sand, Squaw	1650	1670
Slate	1670	1688
Limestone	1688	1708
Sand	1708	1748
Red rock	1748	1760
Sand	1760	1790
Slate	1790	1870
Sand, dark, Berea	1870	1895
Sand, Murrysville	1895	1980
Slate	1980	1995
Sand, Hundred-foot	1995	2100
Slate and shells	2100	2200
Red rock	2200	2440
Slate	2440	2465
Sand, Fourth	2465	2495
Red rock	2495	2500
Sand, Fifth	2500	2535
Slate	2535	3290
Sand, Speechley	3290	3330
Slate and shells	3330	3785
Sand, Bradford (?)	3785	3800
Slate and shells	3800	3828

(27) William Bush farm, American Natural Gas Co., Salem township, Westmoreland County. Well completed in 1909.

To Pittsburgh coal .....505 feet		
Sand, Hundred-foot	1425	1520
" Thirty-foot	1573	1608
" Stray	1924	1954
" Fifth (show gas at 1970)	1954	1982
" Sixth	2012	2037
Slate	2037	2699
Sand, black, very poor, Speechley	2699	2704
" " " " Tiona	2880	......
Slate	......	3490
Sand, black, very poor, Bradford	3490	3498
Slate and shell	3498	3698

(28) George A. Carr farm, Peoples Natural Gas Co. well No. 1844, Salem township, Westmoreland County. Well completed in September, 1922.

To Pittsburgh coal .....380 feet		
Slate	0	95
Coal, Lower Bakerstown	95	97
Slate and shells	97	313
Coal, Upper Freeport	313	316
Slate	316	376
Coal, Upper Kittanning	376	381
Slate	381	400
Sand	400	450
Slate	450	491
Coal, Lower Kittanning	491	495
Slate	495	500
Sand, white, hard	500	685
Slate	685	770
Sand, white and gray, Big Injun	770	1142
Slate	1142	1152
Sand, gray, hard, Squaw	1152	1305
Slate and shells	1305	1479
Sand, white, soft, Murrysville	1479	1612

	From (Feet)	To (Feet)
Slate	1612	1614
Sand, white, Hundred-foot	1614	1706
Slate	1706	1711
Sand, broken, Thirty-foot	1711	1760
Slate and shells	1760	1813
Red rock	1813	1996
Sand, gray, hard, Fourth	1996	2016
Red rock	2016	2087
Slate	2087	2101
Sand, hard, Fifth	2101	2161
Slate	2161	2166
Sand, gray, hard, Sixth	2166	2181
Slate	2181	2220
Sand, pink, hard, Elizabeth	2220	2250
Slate	2250	2730
Sand, pink, good	2730	2748
Slate	2748	2821
Sand, pink, good	2821	2847
Slate	2847	2910
Sand, Speechley (a little gas)	2910	2928
Slate	2928	2966
Sand, pink (a little gas)	2966	2986
Slate	2986	3065
Sand, Tiona	3065	3083
Slate and shells	3083	3415
Slate	3415	3432
Lime	3432	3440
Slate	3440	3450
Unrecorded	3450	3471
Sand, hard, First Bradford	3471	3580
Slate	3580	3581
Sand, Second Bradford	3581	3601
Unrecorded	3601	3975
Sand, Kane (?)	3975	3987
Total depth		4150

(29) J. A. Chambers farm, well No. 1, Pittsburgh Plate Glass Co., Salem township, Westmoreland County.

To Pittsburgh coal .....190 feet		
Clay	0	24
Slate, white	24	124
Red rock	124	154
Slate, white	154	164
Red rock	164	199
Slate, black	199	224
Slate, white	224	311
Lime	311	326
Slate, white	326	460
Lime	460	486
Coal, Upper Freeport	486	490
Slate, white	490	537
Sand, white	537	570
Slate, black	570	682
Slate, white	682	687
Sand, white	687	707
Slate, white	707	766
Sand, white	766	815
Slate, white	815	820
Sand, white	820	861
Coal	861	863
Sand, white	863	911
Slate, white	911	942
Sand, black	942	962
Slate, white	962	966
Lime, Greenbrier	966	995
Sand, white, Seventy-foot	995	1085
Slate, white	1085	1095
Sand, dark, Big Injun	1095	1170
" white, " "	1170	1220
" dark, " "	1220	1285
" white, " "	1285	1335

	From (Feet)	To (Feet)
Sand dark, Big Injun	1335	1425
" white, Squaw	1425	1608
Slate, "	1608	1633
Sand, "	1633	1660
Slate, "	1660	1700
Sand, " } Murrysville	1700	1745
Slate, " } Murrysville	1745	1757
Sand, " } Murrysville	1757	1820
Slate, "	1820	1826
Sand, " Hundred-foot	1826	1960
Slate, "	1960	2005
Sand, "	2005	2039
Slate, "	2039	2065
Red rock	2065	2300
Slate, white	2300	2328
Sand, Fifth	2328	2402
Slate, white	2402	2422
Red rock	2422	2453
Slate and shells	2453	3053
Sand, broken, Speechley Stray	3053	3093
Slate, white	3093	3128
Sand, broken, Speechley	3128	3173
Slate, white	3173	3280

(30) George Kistler farm, Pittsburgh Plate Glass Co., Washington township, Westmoreland County. Well completed October 4, 1909.

To Pittsburgh coal .250 feet		
Gravel	0	45
Slate	45	105
Lime	105	111
Slate (water at 215)	111	300
Coal, Brush Creek	300	302
Slate	302	316
Lime	316	321
Slate	321	390
Coal, Mahoning	390	394
Slate	394	420
Sand	420	445
Slate	445	455
Sand	455	520
Slate	520	600
Sand	600	655
Slate	655	680
Sand	680	847
Slate	847	867
Red rock	867	889
Lime and sand, Greenbrier	889	940
Sand, red (gas)	940	952
Sand, white, Big Injun	952	1315
Slate	1315	1335
Sand, Squaw	1335	1505
Slate	1505	1555
Sand, Berea	1555	1605
Slate	1605	1650
Sand, Murrysville (salt water)	1650	1777
Sand, Hundred-foot (gas at 1917)	1777	1942
Slate	1942	1948
Sand, Thirty-foot	1948	1988
Slate and shells	1988	2008
Red rock	2008	2284
Sand, Fifth	2284	2299
Red rock	2299	2309
Sand, Fifth	2309	2336
Slate	2336	2346
Sand, Sixth	2346	2361
Slate	2361	2390
Sand, Elizabeth (gas at 2395)	2390	2406
Slate and shells	2406	2955
Sand, Speechley Stray	2955	2987

	From (Feet)	To (Feet)
Slate and shells	2987	3073
Sand, Speechley (gas at top of sand)	3073	3100
Slate	3100	3135
Sand, Second Speechley	3135	3164
Slate	3164	3242
Sand, Tiona	3242	3254
Slate	3254	3267
Sand	3267	3295
Slate and shells	3295	3590
Sand, First Bradford	3590	3630
Slate	3630	3635
Sand, First Bradford	3635	3675
Slate	3675	3710
Sand, Second Bradford	3710	3735
Slate and shells	3735	3935

Casing record:
105 feet of $8\frac{1}{4}$ inch
730 " " $6\frac{5}{8}$ "
1906 " " 5/16 inch

(31) Hall Heirs' farm, well No. 4, American Natural Gas Co., Washington township, Westmoreland County. Well completed July 28, 1920.

To Pittsburgh coal .....540 feet.		
Mud	0	10
Slate	10	145
Coal, Upper Freeport	145	148
Slate	148	385
Sand	385	445
Slate	445	460
Sand	400	550
Slate and shells	550	640
Sand, Seventy-foot	640	705
Slate	705	800
Sand, Big Injun	800	1155
Slate and shells	1155	1353
Sand, Murrysville (smell of gas)	1353	1456
Slate	1456	1459
Sand, Hundred-foot	1459	1560
Sand, Thirty-foot	1560	1600
Slate and shells	1600	1680
Red rock	1680	1940
Slate	1940	1945
Sand, Fifth (a little gas)	1945	1990
Slate and shells	1990	2785
Sand, Speechley	2785	2820
Slate	2820	3019
Sand, Sheffield (gas at top)	3019	3025
Slate	3025	3380
Sand, Bradford (gas)	3380	3385
Slate	3385	3465

(32) G. H. Alcorn farm, Peoples Natural Gas Co., well No. 851, Bell township, Westmoreland County. Well completed October 29, 1912.

To Pittsburgh coal .....40 feet		
Coal, Brush Creek	503	......
Coal, Mahoning	563	569
Lime	780	790
Lime	1070	......
Sand, Big Injun	1093	1420
" Squaw	1610	1660
" Berea (gas at 1805)	1795	1855
Red rock	2167	2267
Sandstone	2500	2520
"	3182	3210
"	3285	3340

	From (Feet)	To (Feet)
Slate	3340	3425
Sandstone	3425	3429
Slate	3429	3532
Sandstone	3532	3547
Slate	3547	3736
Sandstone	3736	3751
Slate	3751	3764
Sandstone	3764	3770
Slate	3770	3800

(33) W. T. and T. E. Adair farm, Pittsburgh Plate Glass Co., Bell township, Westmoreland County. Well completed October 6, 1909.

To Pittsburgh coal ....350 feet		
Sand and gravel	0	20
Slate	20	100
Coal, Lower Bakerstown	100	106
Slate, white	106	184
Sand, white	184	290
Coal, Upper Freeport	290	300
Slate, white	300	372
Sand, white	372	425
Slate, black	425	470
Sand, white	470	730
Slate, black	730	752
Red rock	752	755
Slate, white	755	780
Sand, white, Big Injun	780	805
Slate, black (?)	805	1360
Sand	1360	1435
Slate, white	1435	1458
Sand, white, Berea and Murrysville (?)	1458	1568
Slate, white	1568	1585
Sand, white, Murrysville	1585	1605
Slate	1605	1820
Red rock	1820	1920
Slate and shells	1920	2205
Sand, white, Sixth	2205	2225
Slate and shells	2225	2725
Shells, hard	2725	2745
Slate, white	2745	2895
Sand, Speechley	2895	2915
Slate and shells	2915	3360
Shells	3360	3395
Slate, white	3395	3581

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U. S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

PENNSYLVANIA DEPARTMENT OF FORESTS AND WATERS
R. Y. STUART, SECRETARY
TOPOGRAPHIC AND GEOLOGIC SURVEY
GEORGE H. ASHLEY, STATE GEOLOGIST

TOPOGRAPHIC AND GEOLOGIC
ATLAS OF PENNSYLVANIA
GREENSBURG QUADRANGLE
SHEET 37 PLATE I

Base from U. S. Geological Survey topographic map
Surveyed in cooperation with the
Commonwealth of Pennsylvania in 1904

MAP OF THE GREENSBURG QUADRANGLE, PENNSYLVANIA

Showing Topography

Scale $\frac{1}{62500}$

Contour interval 20 feet

Datum is mean sea level

TOPOGRAPHIC AND GEOLOGIC SURVEY
GEORGE H. ASHLEY, STATE GEOLOGIST

AREAL GEOLOGY
(Freeport)

TOPOGRAPHIC AND GEOLOGIC
ATLAS OF PENNSYLVANIA
GREENSBURG QUADRANGLE
SHEET 37 PLATE V

EXPLANATION
SURFICIAL ROCKS

Qal	**Alluvium** (in flood plains of present streams)	PLEISTOCENE
Cw	**Washington group** (sandstone, shale, limestone, and shaly coals; lower half only of formation is present)	PERMIAN
Cm	**Monongahela group** (chiefly shale and limestone, sandstones occasionally prominent; Waynesburg coal at top, Pittsburg coal at base)	PENNSYLVANIAN
Ccm	**Conemaugh group** (shale and sandstone, thin coals and limestones; several fossiliferous horizons)	PENNSYLVANIAN
Ca	**Allegheny group** (Upper Freeport coal and part of underclay; only part of formation exposed)	PENNSYLVANIAN

(Connellsville)

Scale $\frac{1}{62500}$

Contour interval 20 feet

Datum is mean sea level

1925

Geology by C. J. Campbell, C. K. Graeber, C. W. Robinson, P. S. Schoeneck, and M. E. Johnson

Surveyed in 1921

TOPOGRAPHIC AND GEOLOGIC SURVEY
GEORGE H. ASHLEY, STATE GEOLOGIST

MINERAL RESOURCES

TOPOGRAPHIC AND GEOLOGIC
ATLAS OF PENNSYLVANIA
GREENSBURG QUADRANGLE
SHEET 37 PLATE XI

EXPLANATION

Outcrop of Ames limestone

Outcrop of coal beds two feet or more thick

WBG = Waynesburg
BN = "Bench"
RS = Redstone
PGH = Pittsburg
DUQ = Duquesne
UB = Upper Bakerstown
LB = Lower Bakerstown
MA = Mahoning
UF = Upper Freeport

MINES

26 Shipping mine
Numbers correspond to those in list of mines, pages 101,102.

Abandoned mines
Idle mines
Country bank

× Prospect entry

QUARRIES

SS Sandstone quarry
LS Limestone quarry
SH Shale quarry
SH.CL Shale and clay quarry

○ Diamond drill hole

Structure contours on base of Pittsburgh coal bed
Contour interval 50 feet
Datum is mean sea level

(Connellsville)

Scale $\frac{1}{62500}$

Contour interval 20 feet.

Datum is mean sea level.

1925

TOPOGRAPHIC AND GEOLOGIC SURVEY
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OIL AND GAS

TOPOGRAPHIC AND GEOLOGIC
ATLAS OF PENNSYLVANIA
GREENSBURG QUADRANGLE
SHEET 37 PLATE XII

- Show of oil
- Show of gas
- Abandoned gas well
- Dry hole
- Drilling well
- Well location
- Figures in black 2092 denote depth of well
- 20 Full record of well given in appendix

Approximate mean declination 1904

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet

Datum is mean sea level.

1925